Appendix D

Watershed Management Area Analysis

Carlsbad Watershed Management Area Analysis

Lake Henshaw

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Prepared for:
San Diego County Copermittees

Prepared by:

Geosyntec consultants

engineers | scientists | innovators

RICK Engineering Company

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ACRONYMS AND ABBREVIATIONS

%	percent
>	greater than
<	less than
BMP	Best Management Practice
CB	Coarse Bedrock
CEG	Certified Engineering Geologist
CIP	Capital Improvement Project
CLRP	Comprehensive Load Reduction Plan
CSI	Coarse Sedimentary Impermeable
CSP	Coarse Sedimentary Permeable
E_P	Erosion Potential
ET	Evapotranspiration
FB	Fine Bedrock
FEMA	Federal Emergency Management Agency
FIS	Flood Insurance Study
FSI	Fine Sedimentary Impermeable
FSP	Fine Sedimentary Permeable
GIS	Geographic Information System
GLU	Geomorphic Landscape Unit
HA	Hydrologic Area
HCP	Hydromodification Control Plan
HMP	Hydromodification Management Plan
HRU	Hydrologic Response Unit
HSA	Hydrologic Sub Area
HSG	Hydrologic Soil Group
IRWM	Integrated Regional Water Management
JURMP	Jurisdictional Urban Runoff Management Plan
LDW	Land Development Workgroup
LID	Low Impact Development
MAP	Mean Annual Precipitation

ACRONYMS AND ABBREVIATIONS continued

MHPA	Multiple Habitat Planning Area
MS4	Municipal Separate Storm Sewer System
MSCP	Multiple Species Conservation Program
NED	National Elevation Dataset
NPDES	National Pollutant Discharge Elimination System
NRCS	National Resources Conservation Service
PDP	Priority Development Project
RCB	Reinforced Concrete Box
RCP	Reinforced Concrete Pipe
SCAMP	Southern California Aerial Mapping Project
SCCWRP	Southern California Coastal Water Research Project
SD	San Diego
SDRWQCB	San Diego Regional Water Quality Control Board
S_P	Sediment Supply Potential
SSURGO	Soil Survey Geographic Database
TMDL	Total Maximum Daily Load
USGS	United States Geological Survey
WMA	Watershed Management Area
WMAA	Watershed Management Area Analysis
WQIP	Water Quality Improvement Plan
WURMP	Watershed Urban Runoff Management Plan

1. Introduction

1.1.Background

On May 8, 2013 the California Regional Water Quality Control Board, San Diego Region adopted Order No. R9-2013-0001; NPDES No. CAS 0109266, National Pollutant Discharge Elimination System (NPDES) Permit and Waste Discharge Requirements for Discharges from the Municipal Separate Storm Sewer Systems (MS4s) Draining the Watersheds within the San Diego Region (Regional MS4 Permit). The Regional MS4 Permit, which became effective on June 27, 2013, replaces the previous MS4 Permits that covered portions of the Counties of San Diego, Orange, and Riverside within the San Diego Region. There were two main goals for the Regional MS4 Permit:

1. To have more consistent implementation, as well as improve inter-agency communication (particularly in the case of watersheds that cross jurisdictional boundaries), and minimize resources spent on the permit renewal process.
2. To establish requirements that focused on the achievement of water quality improvement goals and outcomes rather than completing specific actions, thereby giving the Copermittees more control over how their water quality programs are implemented.

To achieve the second goal, the Regional MS4 Permit requires that Water Quality Improvement Plans (WQIPs) be developed for each Watershed Management Area (WMA) within the San Diego Region. As part of the development of WQIPs, the Regional MS4 Permit provides Copermittees an option to perform a Watershed Management Area Analysis (WMAA) through which watershed-specific requirements for structural BMP implementation for Priority Development Projects can be developed for each WMA. This report presents the Copermittees' approach and results for the regional elements of the WMAA developed for the San Diego County area.

1.2.Watershed Management Area Analysis (WMAA)

The Regional MS4 Permit, through inclusion of the WMAA, provides an optional pathway for Copermittees to develop an integrated approach for their land development programs by promoting evaluation of multiple strategies for water quality improvement and development of watershed-scale solutions for improving overall water quality in the watershed. The WMAA comprises the following three components as indicated in the Regional MS4 Permit:

1. Perform analysis and develop Geographic Information System (GIS) layers (maps) by gathering information pertaining to the physical characteristics of the WMA (referred to herein as WMA Characterization). This includes, for example, identifying potential areas of coarse sediment supply, present and anticipated future land uses, and locations of physical structures within receiving streams and upland areas that affect the watershed hydrology (such as bridges, culverts, and flood management basins).
2. Using the WMA Characterization results, compile a list of candidate projects that could potentially be used as alternative compliance options for Priority Development Projects. Such projects may include, for example, opportunities for stream or riparian area rehabilitation, opportunities for retrofitting existing infrastructure to incorporate storm

water retention or treatment, or opportunities for regional BMPs, among others. Prior to implementing these candidate projects the Copermittees must demonstrate that implementing such a candidate project would provide greater overall benefit to the watershed than requiring implementation of the onsite structural BMPs. Note, compilation or evaluation of potential projects was not performed as part of this regional effort. Identification and listing of candidate projects will be performed for each WMA through the WQIP process for WMAs that elect to submit the optional WMAA as part of the WQIP.

3. Additionally, using the WMA Characterization maps, identify areas within the watershed management area where it is appropriate to allow for exemptions from hydromodification management requirements that are in addition to those already allowed by the Regional MS4 Permit for Priority Development Projects. The Copermittees shall identify such cases on a watershed basis and include them in the WMAA with supporting rationale to support claims for exemptions.

1.3. Scope of Work for Regional WMAA

In July 2013, the Copermittees elected to fund a regional effort to develop elements of the regional WMAA for the 9 San Diego-area WMAs within the County of San Diego that are currently subject to the Regional MS4 Permit, which include:

- Santa Margarita River (for portion in San Diego County)
- San Luis Rey River
- Carlsbad
- San Dieguito River
- Los Peñasquitos
- Mission Bay & La Jolla Watershed
- San Diego River
- San Diego Bay
- Tijuana River (for portion in San Diego County)

The regional-level information developed through this effort is intended to provide consistency across WMAs and serve as the foundation for developing watershed-specific information for each WMA to be developed through the WQIP process. The regional effort scope of work included:

1. Development of GIS map layers that characterize the WMAs using data previously collected, readily available, and provided by the Copermittees, including:
    a. Description of dominant hydrologic processes, such as areas where infiltration or overland flow likely dominates;
    b. Description of existing streams in the watershed, including bed material and composition, and if they are perennial or ephemeral;
    c. Current and anticipated future land uses;
    d. Potential coarse sediment yield areas; and

    e. Locations of existing flood control structures and channel structures, such as stream armoring, constrictions, grade control structures, and hydromodification or flood management basins.

2. Development of a Microsoft® Excel (Excel) template for use by Copermittees to compile lists of candidate projects for an optional alternative compliance program.
3. Development of additional criteria and analyses to support reinstating the following proposed exemptions that were originally developed in the approved 2011 Final Hydromodification Management Plan but not included in the Regional MS4 Permit unless provided by the Copermittees in the WMAA. In addition, development of the associated Hydromodification Applicability/Exemption Mapping.
    a. Exempt River Reaches including:
        i. San Diego River;
        ii. Otay River;
        iii. San Dieguito River;
        iv. San Luis Rey River; and
        v. Sweetwater River
    b. Stabilized Conveyance Systems Draining to Exempt Water Bodies
    c. Highly Impervious/Highly Urbanized Watersheds and Urban Infill, and
    d. Tidally Influenced Lagoons (where data/study provided)

The scope of work for the regional effort excluded performing analysis within the following areas unless data was readily available, as Copermittees do not have jurisdiction over these areas:

1. State Lands;
2. U.S. Departments of Defense land;
3. U.S. National Forest land;
4. U.S. Department of Interior land and
5. Tribal land

Additional description of excluded areas, for the purposes of the Regional WMAA, is indicated in Section 2.3 Land Uses.

1.4. Project Process

The process for developing the Regional WMAA included close coordination with the Land Development Workgroup (LDW) at key points during the project. The LDW is composed of the 21 San Diego-area Copermittees and serves to develop and implement regional land development plans and programs necessary to support the requirements of the Regional MS4 Permit. The consultant team (Geosyntec Consultants and Rick Engineering Company) presented preliminary project assumptions and methodologies proposed to be used to develop the Regional WMAA to meet the requirements of the Regional MS4 Permit in December 2013. The consultant team incorporated workgroup feedback from this meeting and subsequently presented the preliminary

Regional WMAA project results to the LDW in March 2014, again to receive direction and incorporate input on the preliminary results. Subsequently, the draft report was released to the public in July 2014, by a public workshop that included Consultation Panel members from each of the WMAs on July 29, 2014. This version of the report including all of the input described above is being issued for optional inclusion into the respective WQIP Provision B.3 submittals to the SDRWQCB in December 2014.

1.5. Report Organization

This report is organized as follows:

- Chapter 1 provides the project background and purpose;
- Chapter 2 describes the technical basis for characterizing the WMA;
- Chapter 3 describes the template that can be used by Copermittees to compile the list of candidate projects;
- Chapter 4 summarizes the analyses performed to support reinstating select exemptions from hydromodification control requirements for PDPs;
- Chapter 5 presents the WMAA conclusions;
- Chapter 6 presents the references used for the WMAA;
- Attachment A presents the exhibits and additional supporting information for watershed management area characterization;
- Attachment B presents the exhibits and additional supporting information for hydromodification management applicability/exemptions;
- Attachment C expands on the structure of the geodatabase that hosts the GIS data developed by the WMAA; and
- Attachment D provides a crosswalk between the Regional MS4 Permit requirements for WMAA and this report.

1.6. Terms of Reference

The work described in this report was conducted by Geosyntec Consultants (Geosyntec) and Rick Engineering Company (RICK) on behalf of the County of San Diego and the regional Copermittees.

2. Watershed Management Area Characterization

Watershed health and function are strongly influenced by hydrological and geomorphological processes occurring in the watershed. Both hydrological response and geomorphological response of the watershed are dependent on a variety of physical characteristics of the watershed. To this end, the Regional MS4 Permit specifies a set of data that is required to adequately characterize overall watershed processes as a foundation to enhancing integration and effectiveness of watershed management and water quality programs. The following GIS map layers were developed to characterize the hydrological and geomorphological processes within the Carlsbad WMA:

- Dominant Hydrologic Processes: A description of dominant hydrologic processes, such as areas where infiltration or overland flow likely dominates;
- Stream Characterization: A description of existing streams in the watershed, including bed material and composition, and if they are perennial or ephemeral;
- Land Uses: Current and anticipated future land uses;
- Potential Critical Coarse Sediment Yield Areas; and
- Physical Structures: Locations of existing flood control structures and channel structures, such as stream armoring, constrictions, grade control structures, and hydromodification or flood management basins.

These GIS layers can be used to:

- Identify the nature and distribution of key macro-scale watershed processes;
- Identify potential opportunities and constraints for regional and sub-regional storm water management facilities that can play a critical role in meeting water quality, hydromodification, water supply, and/or habitat goals within the watershed;
- Assist with determining the most appropriate management actions for specific portions of the watershed; and
- Suggest where further study is appropriate.

2.1.Dominant Hydrologic Processes

The Regional MS4 Permit identifies in the provisions related to the WMAA that a description of dominant hydrologic processes within the watershed must be developed, with GIS layers (maps) as output. The Permit specifically calls for processes "*such as areas where infiltration or overland flow likely dominates*." These particular aspects of the hydrological mechanics of watersheds are particularly important when attempting to understand the macro-scale opportunities for locating projects that take advantage of either capturing overland flow for treatment or for infiltration.

Investigation of the dominant hydrologic processes in the San Diego-area watersheds indicates that evapotranspiration (ET) is the most dominant hydrologic process for the region based on review of a published study (Sanford and Selnick, 2013). ET is the sum of evaporation and plant transpiration in the hydrologic cycle that transports water from land surfaces to the atmosphere. This is conclusion is supported by comparing the 30-year average annual rainfall for the study area (San Diego County east of the peninsular divide) of between 15 and 18 inches per year (San Diego County, 2005) to the average annual ET rates. According to the California Irrigation Management Information System (CIMIS) Reference Evapotranspiration Map (CIMIS, 1999), the study area (within Zones 4, 6, and 9) experiences annual reference ET of 46.6, 49.7 and 59.9 inches, respectively. Therefore, theoretically, if all of the annual precipitation for the San Diego-area watersheds remained stationary where it fell and did not either infiltrate or runoff to local waterbodies where it would be conveyed downstream ultimately to the ocean, it all would be consumed by ET. As such, the effect of ET on the overall hydrologic processes within the San Diego watersheds is a function of the temporal scale over which it acts. Precipitation events often produce runoff in these watersheds, particularly in the urbanized portions, based on the topography and land cover that tend to accelerate the conveyance of runoff downstream rather than collecting, storing, or spreading out that then would maximize the effect of ET.

Because this study is focused on developing information and mapping for the portion of the hydrologic process that informs watershed management decisions, i.e., locating beneficial projects in areas of greatest opportunity, the next tier of dominant hydrologic processes are studied and mapped by this project. As such, the study area was characterized, based on the methodology described in the following section, according to the predicted fate of runoff within the watersheds being either overland flow or infiltration after considering the effects of ET (as well as an intermediate category of interflow). Areas that were mapped as overland flow do not necessarily preclude infiltration but rather indicate the dominant expected process that runoff would experience if not intercepted for the express purpose of infiltrating storm water runoff. The Model BMP Design Manual will provide more detailed guidance and procedures for determining the potential for infiltrating captured storm water at the project level irrespective of the mapping produced in the WMAA. To reiterate, the WMAA mapping is to provide macro-scale processes for high-level analysis and to inform decisions affecting regional scales. Furthermore, the Model BMP Design Manual will indicate the degree to which site-scale BMPs can expect to benefit from ET or how ET is considered in the sizing of BMPs. In brief, typical storm water BMPs only store water for a few days and therefore are not really capable of significant volume disposal through ET. However, pervious area dispersion (i.e., directing storm water runoff to flat areas for spreading and infiltration) has appreciable benefits with regard to ET and is a practice promoted in the BMP Design Manual.

The processes of interest are further defined as follows:

Overland flow: This process can be thought of as the inverse of infiltration; precipitation reaching the ground surface that does not immediately soak in must run over the land surface (thus, “overland” flow). It reflects the relative rates of rainfall intensity and the soil’s infiltration capacity: wherever and whenever the rainfall intensity exceeds the soil’s infiltration capacity, some overland flow will occur. Most uncompacted, vegetated soils have infiltration capacities of one to several inches per hour at the ground surface, which exceeds the rainfall intensity of even unusually intense storms. In contrast, pavement and hard surfaces reduce the effective infiltration capacity of the ground surface to zero, ensuring overland flow regardless of the meteorological attributes of a storm, together with a much faster rate of runoff relative to vegetated surfaces.

Infiltration and groundwater recharge: These closely linked hydrologic processes are most apparent near ephemeral and perennial conveyances in the San Diego region. Their widespread occurrence is expressed by the common absence of surface-water channels on even steep (undisturbed) hillslopes. Thus, on virtually any geologic material on all but the steepest slopes (or bare rock), infiltration of rainfall into the soil is inferred to be widespread, if not ubiquitous. With urbanization, changes to the process of infiltration are also quite simple to characterize: some (typically large) fraction of that once infiltrating water is now converted to overland flow.

Interflow: Interflow takes place following storm events as shallow subsurface flow (usually within 3 to 6 feet of the surface) occurring in a more permeable soil layer above a less permeable substrate. In the storm response of a stream, interflow provides a transition between the rapid response from surface runoff and much slower stream discharge from deeper groundwater. In some geologic settings, the distinction between “interflow” and “deep groundwater” is artificial and largely meaningless; in others, however, there is a strong physical discrimination between “shallow” and “deep” groundwater movement. Development reduces infiltration and thus interflow as discussed previously, as well as reducing the footprint of the area supporting interflow volume.

The datasets used, methodology for creating the dominant hydrologic processes maps, and the results are described in the sections below.

2.1.1. Datasets Used for identifying dominant hydrologic processes

The following datasets were used in the analysis:

Dataset	Source	Year	Description
Elevation	USGS	2013	1/3rd Arc Second (~10 meter cells) digital elevation model for San Diego County
Soils Data	SanGIS	2013	NRCS (SSURGO) Database for San Diego County downloaded from SanGIS
Land Cover	SanGIS	2013	Ecology-Vegetation layer for San Diego County downloaded from SanGIS
Geology	Kennedy, M.P., and Tan, S.S.	2002	Geologic Map of the Oceanside 30’x60’ Quadrangle, California, California Geological Survey, Regional Geologic Map No. 2, 1:100,000 scale.

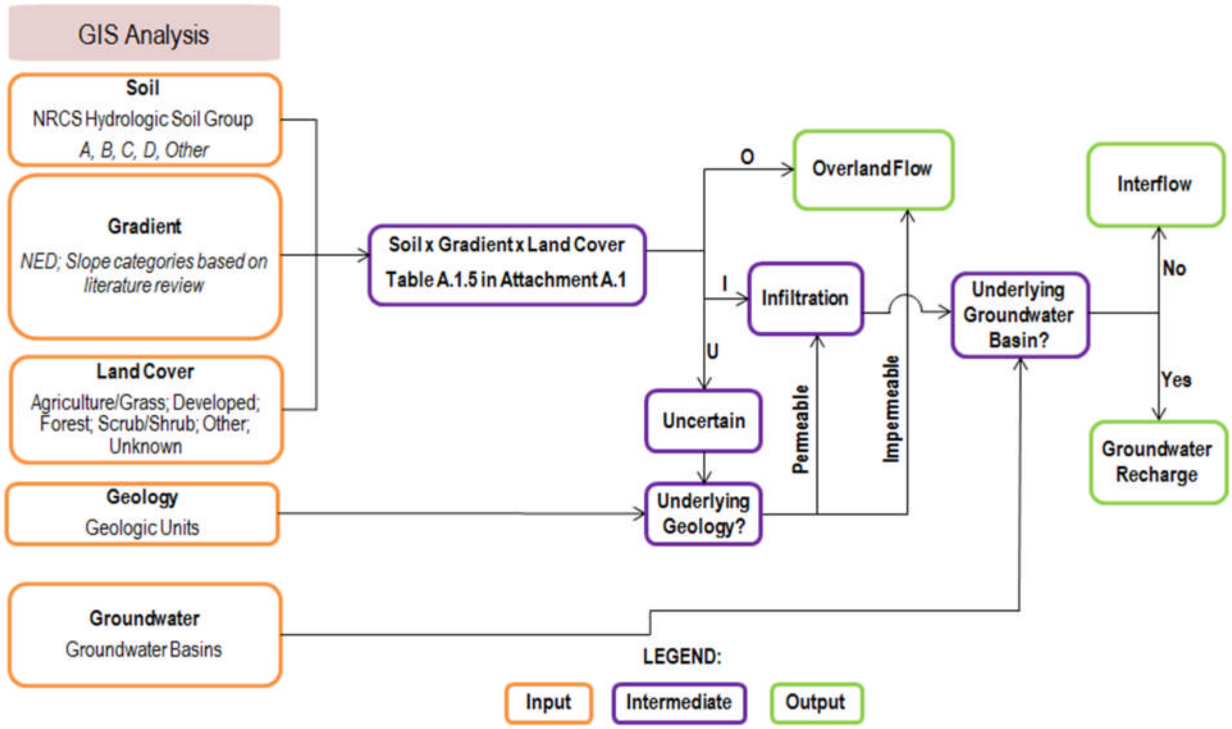
Dataset	Source	Year	Description
	Kennedy, M.P., and Tan, S.S.	2008	Geologic Map of the San Diego 30'x60' Quadrangle, California, California Geological Survey, Regional Geologic Map No. 3, 1:100,000 scale.
	Todd, V.R.	2004	Preliminary Geologic Map of the El Cajon 30'x60' Quadrangle, Southern California, United States Geological Survey, Southern California Aerial Mapping Project (SCAMP), Open File Report 2004-1361, 1:100,000 scale.
	Jennings et al.	2010	"Geologic Map of California," California Geological Survey, Map No. 2 – Geologic Map of California, 1:750,000 scale
Groundwater Basins	SanGIS	2013	Groundwater Basins in San Diego County downloaded from SanGIS

2.1.2. Methodology/Assumptions/Criteria for identifying dominant hydrologic processes

The methodology used to describe dominant hydrologic processes is based on recommendations included in the Southern California Coastal Water Research Project's (SCCWRP) Technical Report 605 titled "Hydromodification Screening Tools: GIS-Based Catchment Analyses of Potential Changes in Runoff and Sediment Discharge" (SCCWRP, 2010). The foundation for this analysis was to incorporate the Report's concept of grouping common hydrologic attributes into Hydrologic Response Units (HRUs). The report states the following:

> *"Grouping common hydrologic attributes across a watershed into a tractable number of Hydrologic Response Units (HRUs: a term first used by England and Holtan 1969) has become a well-established approach for condensing the near-infinite variability of a natural watershed into a tractable number of different elements. The normal procedure for developing HRUs is to identify presumptively similar rainfall–runoff characteristics across a watershed by combining spatially distributed climate, geology, soils, land use, and topographic data into areas that are approximately homogeneous in their hydrologic properties (Green and Cruise 1995, Becker and Braun 1999, Beven 2001, Haverkamp et al. 2005). As noted by Beighley et al (2005), this process of merging the landscape into discrete HRUs is a common and effective method for reducing model complexity and data requirements. Using watershed characteristics to predict runoff is the explicit task of hydrologic models, and there is a host of such models available for application to hydromodification evaluation. For purposes of "screening," however, the goal is simplicity and ease of application even if the precision of the resulting analysis is crude."*

The following process describes the methodology used to define Hydrologic Response Units (HRUs) and then relate the HRUs to the dominant hydrologic processes (i.e., overland flow, interflow, and groundwater recharge) in the Carlsbad WMA.



The first step is to define the HRUs. Once these are defined, the remaining steps determine the dominant hydrologic process.

1. **Integrate data sets used to determine HRU**: Categories for soil type, gradient, and land cover were defined based on readily available GIS datasets for the region and classifications found in relevant literature, as indicated below. The different combinations of these three categories comprise the distinct HRUs.

    - **Soil Categories**: based on National Resource Conservation Service (NRCS) Hydrologic Soil Group (HSG) classifications, which are commonly used to describe runoff/infiltration potential of soils on a regional scale. These categories include: A, B, C, and D. HSG A soils have the lowest runoff potential, while HSG D soils have the highest runoff potential.

    - **Gradient Categories**: based on slope ranges found in a review of relevant literature identified in Chapter 6. The spatial processing of the slope categories utilized the United States Geologic Survey (USGS) National Elevation Dataset (NED). Slopes were grouped (bins) into the following ranges: 0% to 2%; 2% to 6%; 6% to 10%; and greater than 10%. The 2% and 6% slope thresholds were based on slope ranges included in Table A.1.1 (McCuen, 2005) presented in Attachment A.1. This table provides runoff coefficients as a function of slope, soil group, land cover, and return period and was used for subsequent steps in the mapping effort. The 10% slope threshold was used in SCCWRP's Technical Report 605 (SCCWRP, 2010) and is a logical cutoff since slopes steeper than 10% are assumed to be dominated by overland flow.

- **Land Cover Categories**: were defined using the Ecology Vegetation GIS map layer developed by the City of San Diego, the County of San Diego and SANDAG and downloaded from SanGIS (2013). The vegetation categories in the GIS layer were grouped (Table A.1.2 in Attachment A.1) to match the following categories used in SCCWRP's Technical Report 605 (SCCWRP, 2010): Agriculture/Grass; Developed; Forest; Scrub/Shrub, Other (Water), and Unknown.

2. **Evaluate Land Cover**: Land cover categories for Agriculture/Grass, Forest, Scrub/Shrub and Other were related to land use categories defined in Table A.1.1 as shown in Table A.1.3 in Attachment A.1. Relating a land use category for the Developed land cover category was not necessary because all Developed cover was assumed to have overland flow as its dominant hydrologic process.

3. **Determine Hydrology Characteristics for Land Covers**: For each of the land cover/land use categories listed in Table A.1.3, the ratio of precipitation lost to evapotranspiration (i.e. an evapotranspiration coefficient) was estimated using Table A.1.1 using the process described below. Since precipitation is considered to be the sum of the resulting runoff, infiltration, and evapotranspiration, the coefficients for these three hydrologic pathways sum to one, as indicated below.

   Runoff Coefficient + Infiltration Coefficient + Evapotranspiration Coefficient = 1

   i) **Estimate Evapotranspiration**: To estimate the evapotranspiration (ET) coefficient for each land cover, first the runoff coefficient was identified in Table A.1.1 for the highest runoff potential (i.e., Group D soil and 6%+ slope) and most common storm conditions (i.e., storm recurrence intervals less than 25 years). The infiltration for these high runoff conditions was assumed to be negligible, resulting in an infiltration coefficient of zero. Since the sum of the three coefficients should sum to one, the ET coefficient was assumed to be the remaining difference (i.e., ET Coefficient = 1 – Runoff Coefficient). The ET coefficient calculated for the highest runoff potential was then applied to all soil types and slopes within that land use category. The calculated ET coefficient for each applicable HRU is provided in Table A.1.4 in Attachment A.1. The ET coefficient for HRUs that have a Developed land cover or a gradient greater than 10% were not calculated since these HRUs were assumed to have overland flow as the dominant hydrologic process.

   ii) **Estimate Infiltration**: The infiltration coefficient for each applicable HRU (i.e., combination of soil, gradient, and land cover) was estimated by subtracting both the runoff coefficient, provided in Table A.1.1, and the ET coefficient, calculated in step 3(i), from one (i.e., Infiltration Coefficient = 1 – Runoff Coefficient – ET Coefficient). The calculated infiltration coefficient for each applicable HRU is provided in Table A.1.4 in Attachment A.1.

   iii) **Estimate Runoff**: For each applicable HRU, the runoff coefficient was divided by the infiltration coefficient to obtain a ratio representing the potential for runoff or infiltration. The higher the ratio, the greater the potential for runoff to be a more dominant hydrologic process than infiltration. Similarly, the lower the ratio, the greater the potential for infiltration to be a more dominant hydrologic process than runoff. The calculated runoff to infiltration ratios are provided in Table A.1.4 in Attachment A.1.

4. **Associate Runoff and Infiltration to HRUs**: The following designations were assigned to each applicable HRU based on the runoff to infiltration ratio (i.e., runoff coefficient/infiltration coefficient). These designations were based on best engineering judgment with the underlying assumption that if a runoff or infiltration coefficient is more than 50% greater than its counterpart, then the prevailing process is considered dominant.

    - HRUs with runoff to infiltration ratios greater than 1.5 (3:2 ratio) were assumed to have relatively high runoff and overland flow was considered its dominant hydrologic process. These HRUs are designated by the letter "O" (Overland flow is dominant process) in Tables A.1.4 and A.1.5 in Attachment A.1.

    - HRUs with runoff to infiltration ratios less than 0.67 (2:3 ratio) were assumed to have relatively high infiltration and its dominant hydrologic process was either interflow or groundwater recharge, based on analysis described in subsequent steps. These HRUs are designated by the letter "I" (Interflow is dominant process) in Tables A.1.4 and A.1.5.

    - For HRUs with runoff to infiltration ratios between, and including, 1.5 and 0.67 it was uncertain whether it was dominated by overland flow or infiltration. These HRUs are designated by the letter "U" (Dominant process is uncertain) in Tables A.1.4 and A.1.5.

    - For HRUs that have a Developed land cover or a gradient greater than 10%, the runoff to infiltration ratios were not calculated because these HRUs were assumed to have overland flow as the dominant hydrologic process. These HRUs are designated by the letter "O" (Overland flow is dominant process) in Table A.1.5.

5. **Uncertain HRUs Assignment**: For HRUs with an uncertain designation ("U") in Table A.1.5 in Attachment A.1, the underlying regional geology (Kennedy and Tan, 2002 & 2008; Todd, 2004 and Jennings et al., 2010) was used to evaluate whether overland flow or infiltration were dominant. If the underlying geology was considered impermeable, then these uncertain areas were considered to have overland flow as its dominant hydrologic process. If the underlying geology was considered permeable, then these uncertain areas were considered to be dominated by infiltration. The determination of whether a geologic unit is impermeable or permeable was based on desktop evaluation and the best professional judgment of a Certified Engineering Geologist (CEG). This analysis was performed in GIS and is illustrated in the flowchart above.

6. **Associate Infiltration HRUs with Known Groundwater Basins**: For HRUs with relatively high infiltration and have a designation of "I" in Table A.1.5 in Attachment A.1,

the presence or absence of a regional groundwater basin (SanGIS, 2013) underlying these areas determined whether the dominant hydrologic process was designated as interflow or groundwater recharge. The groundwater recharge hydrologic process was assigned as dominant for those applicable areas which had an underlying groundwater basin. The interflow hydrologic process was assigned as dominant for those applicable areas which did not have an underlying groundwater basin directly below it. This analysis was performed in GIS and is illustrated in the flowchart above.

7. **Resulting HRU Data:** The resulting GIS map of dominant hydrologic processes was reviewed by engineering professionals familiar with the hydrology in the County of San Diego to confirm that the mapping is consistent with their experience working in the region.

2.1.3. Results for identifying dominant hydrologic processes

The resulting GIS map showing the spatial distribution of dominant hydrologic processes (i.e., overland flow, interflow, and groundwater recharge) within the Carlsbad WMA is provided in Attachment A.1. An ArcMap document file which presents the results from each step of the methodology is included in Attachment C, as well as a Google Earth KMZ file. Based on this analysis, overland flow is the predominant hydrologic process in all this WMA, which is consistent with the experience of engineering professionals familiar with the hydrology of the County of San Diego.

Summary of Deliverables for Dominant Hydrologic Processes

Format	Item	Description	Location
Report	Figure	"Dominant Hydrologic Processes"	Attachment A.1
GIS	Map Group Title	Hydrologic Processes	Attachment C.1
	Map Layer Title	Soil Land Cover Slope Hydrologic Response Unit Initial Rating Permeability Groundwater Basin Dominant Hydrologic Processes	
	Geodatabase Feature Dataset	HydrologicProcesses	
	Geodatabase Feature Class	HRUAnalysis	
	Geodatabase Geometry Type	Polygon	
KMZ [1]	KMZ File Name	Dominant Hydrologic Processes	Attachment C.2

[1] To enhance the utilization of this data, the Dominant Hydrological Processes map is provided in both traditional GIS file format (ESRI software license purchase required) and as a Google Earth KMZ (Keyhole Markup Language/Zipped) file that can be viewed with the free download version of Google Earth (http://www.google.com/earth/).

2.1.4. Limitations for identifying dominant hydrologic processes

The resulting GIS map layer only lists the dominant hydrological process (i.e., an HRU assigned a dominant process of overland flow can also experience small amounts of infiltration) and provides a useful, rapid framework to perform screening-level analysis that is appropriate for watershed-scale planning studies. When more precise estimates are required for a particular site and subarea it is recommended that this analysis be augmented with site-specific analysis.

2.2.Stream Characterization

For the purpose of WMAA, the Regional MS4 Permit requires a description of existing streams in the watershed, including bed material and composition, and if they are perennial or ephemeral. Under the Regional WMAA, this analysis was prepared for 27 streams throughout the San Diego Region agreed upon by the consultant team and Copermittees. Within the Carlsbad WMA, stream characterization and detailed mapping is provided for Buena Vista Creek, Agua Hedionda Creek, San Marcos Creek, Encinitas Creek, Cottonwood Creek, and Escondido Creek as shown on the exhibit titled "Watershed Management Area Streams" located in Attachment A.2.

2.2.1. Datasets Used for stream characterization

The following data were referenced for the purpose of stream characterization:

- USGS National Hydrography Dataset, downloaded from USGS November 2013
- USGS 7.5-minute quadrangles, compiled image of quadrangles covering San Diego County, various dates
- Floodplains: "National Flood Hazard Layer," provided by Federal Emergency Management Agency October 2012
- Various datasets provided by Copermittees depicting existing storm water conveyance infrastructure within their jurisdictions.
- Aerial photography by Digital Globe dated 2012

2.2.2. Methodology/Assumptions/Criteria for stream characterization

The analysis was prepared by digitizing each of the 27 streams based on review of data listed above. Within the pre-existing datasets depicting streams, floodplains, or infrastructure, no single dataset included a complete, accurate alignment of each stream. Digitizing the streams based on review of all of the data listed above allowed creation of GIS linework with a continuous corrected alignment for each stream. The following data were recorded as GIS attributes for each stream as the stream was digitized:

- River name
- Reach type (engineered or natural, constrained or un-constrained)
- Bed material
- Bank material
- Hydrographic category (perennial or intermittent)

The attributes listed above were collected manually based on interpretation of the reference data. Assumptions used in making the interpretations are listed below. The ***Hydrographic Category*** section below will provide the rationale as to why perennial and intermittent were the hydrographic categories chosen for this WMAA and not perennial and ephemeral.

Note that stream classification was not prepared within areas of Federal/State/Indian lands unless data was readily available. Stream lines were prepared within these areas for continuity, but some data fields were not populated within these areas.

Reach Type

Streams were classified as either engineered or natural, and either constrained or un-constrained. See the exhibit titled, "Watershed Management Area Streams by Reach Type" in Attachment A.2. The purpose of this exercise was to identify whether the stream has been modified by human activity within the stream itself, which may include addition of crossing structures, stabilization of banks, dredging, or any other human activity. This aids the identification of physical structures including stream armoring, constrictions, grade control, and other modifications as required by the Regional MS4 Permit.

Classification of the streams as either "**engineered"** or **"natural"** was based on the following criteria:

<u>Engineered</u>

- A classification of "engineered" was assigned where the stream itself has been modified by human activity.
- All culvert/bridge/pipe crossings either provided in the Copermittes' storm water conveyance system data or clearly visible on the aerial photo have been assigned as engineered within the limits of the crossing.
- If the Copermittees did not provide storm water conveyance system data for the dirt road crossings/dip sections the streams have been assigned as engineered within the limits of the crossing. These crossings may or may not have culverts.
- If the Copermittees' storm water conveyance system data stated the facility is a detention or desilting basin, they were assigned as engineered.
- Golf courses have been assigned as engineered.
- If aerial photography showed large water bodies (lake, pond, irrigation pond, etc.) they were assigned as engineered.
- If the storm water conveyance system data provided by the Copermittees has identified the stream as "rockbs", the assumption has been made that these streams have rocks on their bottom and the sides ("bs"), and have been assigned as engineered.
- Sand mining operations have been assigned as engineered. Sand mining is an operation that is in continuous flux and does not typically result in a discrete, engineered geometry in any given channel cross section until restoration is implemented at the conclusion of the sand mining operation. It is assigned as engineered to acknowledge human alteration of the stream.

<u>Natural</u>

- Streams that have no apparent alteration within the stream itself by human activity have been assigned as natural.

Classification of the streams as either **"constrained"** or **"un-constrained"** was based on the following criteria:

Constrained

- All culvers/bridge/pipe crossings either provided in the Copermittes' storm water conveyance system data or clearly visible on the aerial photo have been assigned as constrained.
- If the Copermittees did not provide storm water conveyance system data for the dirt road crossings/dip sections the streams have been assigned as constrained. These crossings may or may not have culverts.
- If the Copermittees' storm water conveyance system data stated the facility is a detention or desilting basin, they were assigned as constrained.
- Golf courses have been assigned as constrained if located within the Federal Emergency Management Agency (FEMA) floodway based on the "National Flood Hazard Layer" data.
- The USGS National Hydrographic Dataset in their hydrographic category had assigned some reaches as artificial paths. In these situations and if the aerial photography shows large water bodies (lake, pond, irrigation pond, etc.) these streams have been assigned as constrained.
- Sand mining operations located within the FEMA floodway based on the "National Flood Hazard Layer" have been assigned as constrained.

Un-constrained

- Golf courses have been assigned as un-constrained if not located within the FEMA floodway based on the "National Flood Hazard Layer" data.
- Sand mining operations not located within the FEMA floodway based on the "National Flood Hazard Layer" data have been assigned un-constrained.
- If the stream is located within the FEMA floodway based on the "National Flood Hazard Layer" and there is available land in the floodway fringe (the area between the floodway and the 100-yeaer floodplain) the area has been assigned un-constrained. Note that there may be only one side or both sides of the stream with available land in the floodway fringe therefore a note was added as to which side of the stream is constrained and un-constrained.
- If the stream is located within a FEMA 100-year floodplain based on the "National Flood Hazard Layer" data with no floodway and the FEMA floodplain width is not within an existing development or bordered by roads have been assigned as un-constrained.

Bed Material and Bank Material

The following bed and bank materials were identified:

- Concrete
- Riprap
- Pipe / culvert
- Earth

The assumptions made to identify the streams bed and bank materials were based on the following criteria:

- If the data provided by the Copermittees provided information about the stream bed and bank material, the provided data was used for the bed and bank material.
- Generally the data provided by the Copermittees did not identify the crossing type (pipe, box culvert, bridge with or without piers, etc.) or the material (RCP, RCB, earth, riprap, concrete, etc.). In that case, all culvert/bridge/pipe crossings were assigned as pipe/culvert for the bed and bank material.
- If the Copermittees did not provide data for the dirt road crossings/dip sections the bed and bank material have been assigned as pipe/culvert. These crossings may or may not have culverts.
- If the Copermittees’ storm water conveyance system data stated the facility is a detention or desilting basin, the bed and bank material have been assigned as earth.
- If aerial photography showed large water bodies (lake, pond, irrigation pond, etc.) they were assigned as earth bed and bank material. The USGS National Hydrographic Dataset in their hydrographic category had assigned some of these types of reaches as artificial paths.
- Sand mining operations within the stream have been assigned as earth for bed and bank material.
- If the Copermittees did not provide data for the stream material the bed and bank material have been assigned based on the aerial photography.

See exhibits titled, "Watershed Management Area Streams by Bed Material" in Attachment A.2.

After stream bed and bank material was classified, earthen reaches were further classified by geologic group. This was accomplished by intersecting the streams with the geologic group layer that had been prepared for use in the dominant hydrologic process and potential coarse sediment yield analyses. The result is displayed in exhibits titled, "Watershed Management Area Streams by Geologic Group" in Attachment A.2.

Hydrographic Category

Streams were classified as "perennial" or "intermittent." See exhibits titled, "Watershed Management Area Streams by Hydrographic Category" in Attachment A.2. Classification was obtained from the USGS National Hydrography Dataset (NHD). The definitions of these categories in the USGS National Hydrography Dataset are:

- **Perennial**: Contains water throughout the year, except for infrequent periods of severe drought.
- **Intermittent**: Contains water for only part of the year, but more than just after rainstorms and at snowmelt.

While the specific Regional MS4 Permit language requested classification of perennial or ephemeral, rather than perennial or intermittent, the data that was referenced in order to classify streams did not include "ephemeral" streams. For reference, the USGS National Hydrography

Dataset definition of "ephemeral" is: "contains water only during or after a local rainstorm or heavy snowmelt." None of the stream reaches in the study were classified as ephemeral in the NHD dataset, therefore none are classified as ephemeral in the WMAA product. The City of San Diego provided a map titled “City of San Diego Stream Survey” dated April 3, 2013 prepared by AMEC that shows streams that are “dry” and streams that are “flowing”. This information in conjunction with the other parameters listed in this section was used to determine if a stream was perennial or intermittent.

USGS NHD includes hydrographic category classification for many of the streams. However data was not available for all reaches of all streams. In order to classify reaches of streams that did not already contain this data in NHD, these assumptions were made:

- The USGS NHD information for the stream hydrographic category has been used when available.
- When USGS NHD has “artificial paths” for portions of the stream, the hydrographic category of the upstream portion of the stream have been assigned to the stream unless other assumptions took precedence.
- If aerial photography shows large waterbody (lake, pond, irrigation pond, etc.) perennial has been assumed for the hydrographic category.
- For ponded areas shown on the aerial photography and if the USGS 7.5-minute quadrangles shows cross hatching for the area, intermittent has been assigned unless the upstream portion of the stream was assigned as perennial pursuant to the USGS National Hydrography Dataset then assigned perennial for the ponded area.
- USGS has a dashed line for intermittent streams. USGS has a solid line for perennial streams. In some situations this information was used to assist in the determination of assigning perennial or intermittent to a stream.

2.2.3. Results for stream characterization

The 27 streams and data are contained in a GIS file titled "SD_Regional_WMAA_Streams" located in Attachment C. The streams are shown in watershed maps included in Attachment A.2.

Summary of Deliverables for Stream Characterization

Format	Item	Description	Location
Report	Title of Figures	• "Watershed Management Area Streams" • "Watershed Management Area Streams by Hydrographic Category" • "Watershed Management Area Streams by Bed Material" • "Watershed Management Area Streams by Geologic Group" • "Watershed Management Area Streams by Reach Type"	Attachment A.2
GIS	Map Group Title	Not Grouped	Attachment C.1
	Map Layer Title	SD_Regional_WMAA_Streams	

Format	Item	Description	Location
	Geodatabase Feature Dataset	Streams	
	Geodatabase Feature Class	SD_Regional_WMAA_Streams	
	Geodatabase Geometry Type	Line	
KMZ [1]	KMZ File Name	SD_Regional_WMAA_Streams	Attachment C.2
[1] To enhance the utilization of this data, the Stream Characterization map is provided in both traditional GIS file format (ESRI software license purchase required) and as a Google Earth KMZ (Keyhole Markup Language/Zipped) file that can be viewed with the free download version of Google Earth (http://www.google.com/earth/).			

In addition to the 27 streams that were subject of detailed analysis, NHD streams have been included on maps and within the geodatabase for reference. The NHD stream alignments have not been corrected and in some cases may be inconsistent with the existing infrastructure. The NHD streams are contained in a GIS file titled, "SD_NHD_Streams."

2.2.4. Limitations for stream characterization

- Only a desktop analysis was performed and no field verification was conducted.
- Infrastructure is only based on storm water conveyance system data provided by Copermittees or clearly visible on aerial photography. If the Copermittee used a numbering or lettering system for describing bed and bank material for example, since the metadata was not provided the bed and bank material could not be verified.
- In some instances concrete channels cannot be identified on aerial photography if it is filled with sediment and/ or vegetation.

2.3.Land Uses

For the purpose of the WMAA, the Regional MS4 Permit requires a description of current and anticipated future land uses. This is presented in the final GIS deliverable as "Land Use Planning" and includes the following representations of land uses in the watersheds: existing land uses, planned land uses, developable lands, redevelopment and infill areas, floodplains, Multiple Species Conservation Program (MSCP) designated areas, and areas not within the Copermittees' jurisdictions (tribal lands, state lands, and federal lands).

2.3.1. Datasets Used for land uses

The following existing regional datasets were referenced to meet this requirement:

- Municipal boundaries: "Municipal_Boundaries" dated August 2012, available from SanGIS/SANDAG
- Ownership: "Parcels" dated December 2013, available from SanGIS/SANDAG
- Existing land use: "SANGIS.LANDUSE_CURRENT" dated December 2012, available from SanGIS/SANDAG (existing land use)
- Planned land use: "PLANLU" (Planned Land Use for the Series 12 Regional Growth Forecast (2050)), dated December 2010, available from SanGIS/SANDAG
- Developable land: "DEVABLE" (Land available for potential development for the Series 12 Regional Growth Forecast), dated December 2010, available from SanGIS/SANDAG
- Redevelopment and infill areas: "REDEVINF" (Redevelopment and infill areas for the Series 12 Regional Growth Forecast), dated December 2010, available from SanGIS/SANDAG
- Floodplains: "National Flood Hazard Layer" provided by Federal Emergency Management Agency October 2012
- Multiple Species Conservation Program (MSCP), total of four datasets available from SanGIS/SANDAG: "MHPA_SD," dated 2012, (Multiple Habitat Planning Areas for City of San Diego); "MSCP_CN," dated 2009 (designations of the County of San Diego's Multiple Species Conservation Program South County Subregional Plan); "MSCP_EAST_DRAFT_CN," dated 2009 (draft East County MSCP Plan); and "Draft_North_County_MSCP_Version_8.0_Categories," dated 2008 (draft North County MSCP Plan)

2.3.2. Methodology/Assumptions/Criteria for land uses

The existing regional datasets for existing land use, planned land use, developable land, redevelopment and infill areas, floodplains, and MSCP designated areas were referenced with no modifications. Areas not within the Copermittees' jurisdictions (tribal lands, state lands, and federal lands) were compiled from SanGIS parcel data (December 2013) based on the "ownership" value. The owners listed below were excluded from the Copermittees jurisdictions and represent the "Federal/State/Indian" layer, which is displayed on various maps included in Attachment A.2.

- Bureau of Land Management
- California Department of Fish and Game
- Indian Reservations
- Military Reservations
- Other Federal

- State
- State of California Land Commission
- State Parks
- U.S. Fish and Wildlife Service
- U.S. Forest Service

When available, relevant data from these areas was included in analyses (e.g., developable land areas within Federal/State/Indian areas). Stream lines were prepared within these areas for continuity. However, stream classification (e.g., bed and bank material) was not prepared within these areas unless data was readily available (e.g., hydrographic category data available from NHD)

2.3.3. Results for land uses

The existing regional datasets are compiled into the Geodatabase in a group titled, "Land Use Planning." Current and anticipated future land uses are depicted in watershed maps included in Attachment C. Federal/State/Indian Lands are also referenced on all other map exhibits included in Attachment A.2.

Summary of Deliverables for Land Uses

Format	Item	Description	Location
Report	Title of Figures	• "Existing Land Use" • "Planned Land Use" • "Developable Land" • "Redevelopment and Infill Areas"	Attachment A.3
GIS	Map Group Title	Land Use Planning	Attachment C.1
	Map Layer Title	Municipal Boundaries Federal/State/Indian Lands SanGIS_ExistingLandUse SanGIS_PlannedLandUse SanGIS_DevelopableLand SanGIS_RedevelopmentandInfill FEMA Floodplain MHPA_SD MSCP_CN MSCP_EAST_DRAFT_CN Draft_North_County_MSCP_Version_8_Categories	
	Geodatabase Feature Dataset	LandUsePlanning	
	Geodatabase Feature Class	SanGIS_MunicipalBoundaries Federal_State_Indian_Lands SanGIS_ExistingLandUse SanGIS_PlannedLandUse SanGIS_DevelopableLand	

Format	Item	Description	Location
		SanGIS_RedevelopmentandInfill FEMA_NFHL SanGIS_MHPA_SD SanGIS_MSCP_CN SanGIS_MSCP_EAST_DRAFT_CN SanGIS_Draft_North_County_MSCP_Version_8_Categories	
	Geodatabase Geometry Type	Polygon	
KMZ [1]	KMZ File Name	Municipal Boundaries Federal/State/Indian Lands Floodplains Due to file size limitations, SanGIS land use datasets were not converted to KMZ.	Attachment C.2

[1] To enhance the utilization of this data, the Land Uses map is provided in both traditional GIS file format (ESRI software license purchase required) and as a Google Earth KMZ (Keyhole Markup Language/Zipped) file that can be viewed with the free download version of Google Earth (http://www.google.com/earth/).

2.3.4. Limitations

Some jurisdictions may have compiled GIS land use layers that include more detailed or more current information than the regional datasets available from SanGIS. SanGIS layers were selected for the Regional WMAA to provide consistent land use characterization region-wide, and to provide for repeatability of GIS analyses when a land use layer is required for input data. The definition of non-Copermittee areas identified in this document as "Federal/State/Indian Lands" is for the Regional WMAA. Some WQIPs may define non-Copermittee areas differently.

2.4. Potential Critical Coarse Sediment Yield Areas

The Regional MS4 Permit identifies in the provisions related to the WMAA that potential coarse sediment yield areas within the watershed be identified, with GIS layers (maps) as output. With regard to the function and importance of coarse sediment, SCCWRP Technical Report 667 titled "Hydromodification Assessment and Management in California" states the following:

"Coarse sediment functions to naturally armor the stream bed and reduce the erosive forces associated with high flows. Absence of coarse sediment often results in erosion of in-channel substrate during high flows. In addition, coarse sediment contributes to formation of in-channel habitats necessary to support native flora and fauna."

This report identifies the potential critical coarse sediment yield areas for the Carlsbad WMA in compliance with this permit provision. The applied datasets and methodologies for identifying the coarse sediment yield areas, along with their respective results, are described in the sections below.

2.4.1. Datasets Used for identifying potential critical coarse sediment yield areas

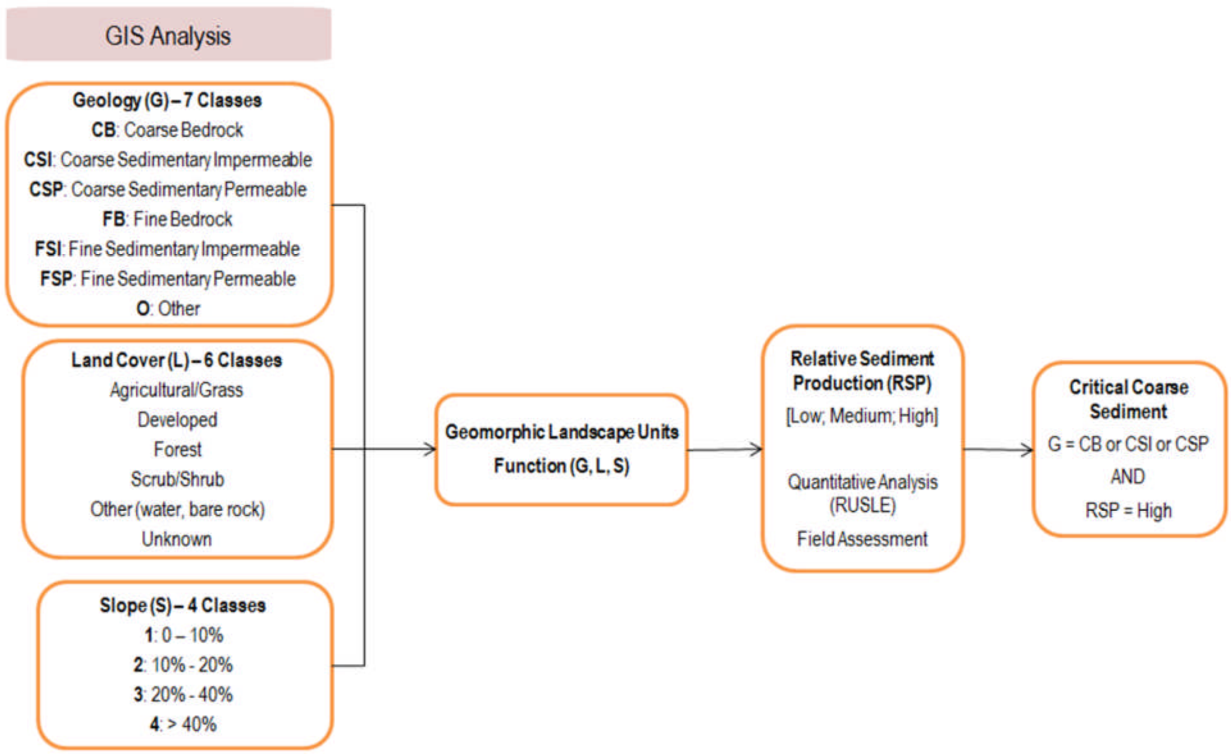
The following datasets were used in the analysis

Dataset	Source	Year	Description
Elevation	USGS	2013	1/3rd Arc Second (~10 meter cells) digital elevation model for San Diego County
Land Cover	SanGIS	2013	Ecology-Vegetation layer for San Diego County downloaded from SanGIS
Geology	Kennedy, M.P., and Tan, S.S.	2002	Geologic Map of the Oceanside 30'x60' Quadrangle, California, California Geological Survey, Regional Geologic Map No. 2, 1:100,000 scale.
	Kennedy, M.P., and Tan, S.S.	2008	Geologic Map of the San Diego 30'x60' Quadrangle, California, California Geological Survey, Regional Geologic Map No. 3, 1:100,000 scale.
	Todd, V.R.	2004	Preliminary Geologic Map of the El Cajon 30'x60' Quadrangle, Southern California, United States Geological Survey, Southern California Areal Mapping Project (SCAMP), Open File Report 2004-1361, 1:100,000 scale.
	Jennings et al.	2010	"Geologic Map of California," California Geological Survey, Map No. 2 – Geologic Map of California, 1:750,000 scale

2.4.2. Methodology/Assumptions/Criteria for identifying potential critical coarse sediment yield areas

The methodology used to identify coarse sediment yield areas is based on Geomorphic Landscape Unit (GLU) methodology presented in the SCCWRP Technical Report 605 titled

"Hydromodification Screening Tools: GIS-Based Catchment Analyses of Potential Changes in Runoff and Sediment Discharge" (SCCWRP, 2010). Geomorphic Landscape Units characterize the magnitude of sediment production from areas through three factors judged to exert the greatest influence on the variability on sediment-production rates: geology types, hillslope gradient, and land cover. The GLU approach provides a useful, rapid framework to identify sediment-delivery attributes of the watershed. The process to integrate these factors into GLUs is indicated in the flow chart below.



The following steps were used to define Geomorphic Landscape Units (GLUs), which were then related to the coarse sediment and critical coarse sediment yield areas in the Carlsbad WMA.

1. **Integrate data sets used to determine GLU:** Categories for geology, gradient, and land cover were defined based on readily available GIS datasets for the region and classifications found in relevant literature listed in Chapter 6. The different combinations of these categories make up distinct GLUs.

    - **Geologic Categories**: based on methodology listed in Attachment A.4.1 of Attachment A.4. Resulting geologic categories from this analysis are: Coarse Bedrock (CB), Coarse Sedimentary Impermeable (CSI), Coarse Sedimentary Permeable (CSP), Fine Bedrock (FB), Fine Sedimentary Impermeable (FSI), Fine Sedimentary Permeable (FSP), and Other (O). An exhibit showing the regional geology groupings is presented in Attachment A.4.

    - **Land cover categories**: defined using the Ecology Vegetation GIS map layer developed by the City of San Diego, the County of San Diego and SANDAG which were downloaded from SanGIS (2013). The vegetation categories in the GIS layer were grouped (Table A.1.2 in Attachment A.1) to match the following categories used in SCCWRP's Technical Report 605 (SCCWRP, 2010): Agriculture/Grass; Developed; Forest; Scrub/Shrub, Other (Water) and Unknown.

- **Gradient Categories**: based on slope ranges found in a review of relevant literature (GLU methodology applied in California) listed in Chapter 6. The spatial processing of the slope categories utilized the USGS National Elevation Dataset (NED). Slope ranges used include: 0% to 10%, 10% to 20%, 20% to 40%, and greater than 40%.

2. **GLU Union Results**: GIS mapping exercise for the study area resulted in 166 GLUs within the 9 WMAs in San Diego County. Table A.4.2 in Attachment A.4 provides the list of the 166 GLUs.

For implementing hydromodification management performance standards in the Regional MS4 Permit, the Copermittees need to identify Critical Coarse Sediment Yield areas in the study region. To provide information on the identification of Critical Coarse Sediment yield, the study assumed that critical coarse sediment would be generated from GLUs that are composed of geologic units likely to generate coarse sediment (based on the methodology listed in Step 3) and have the potential for high relative sediment production (as estimated using the methodology listed in Step 4).

3. **Define Pertinent Geologic groups**: the geologic groups (Attachment A.4.1) considered in this study to have the potential to generate coarse sediment are Coarse Bedrock (CB), Coarse Sedimentary Impermeable (CSI), and Coarse Sedimentary Permeable (CSP). An exhibit showing the regional geologic grouping is presented in Attachment A.4.
4. **Relate GLU to Sediment Production**: For assigning GLUs with a relative sediment production, the following methodology was utilized:
    - Conducted quantitative analysis to assign relative sediment production. Analysis was performed based on the assumption that sediment production from an area is proportional to the soil loss from the area, as evaluated using standard soil loss equation. Detailed analysis steps are documented in Attachment A.4.2;
    - To validate the quantitative assignment above, a qualitative field assessment was conducted for 40 sites. Site selection and findings from the field assessment is documented in Attachment A.4.3.
    - The result of the field assessment indicated a 65% match between field conditions and the quantitative assignments. The mismatches are attributed to differences in percent land cover as assumed for the quantitative analysis and those observed in the field. As such, the quantitative assignments were considered to be valid for the purposes of assigning relative sediment production.

2.4.3. Results for identifying potential critical coarse sediment yield areas

The resulting GIS maps showing the spatial distribution of geologic grouping and critical coarse sediment yield areas within the Carlsbad WMA are provided in Attachment A.4. An ArcMap document which presents the results from each step of the methodology is included in Attachment C. Based on this analysis it was estimated that 8.1% of the study area is a potential critical coarse sediment yield area.

As a result of the regional-scale datasets, and commensurate data resolution, used to map the potential critical coarse sediment yield areas, some areas may have been mapped that in reality do not produce critical coarse sediment as they are existing developed areas. As such, an opportunity for jurisdictions to incorporate more refined data into the preliminary WMAA GIS dataset based on local knowledge and review of current aerial images was provided. The City of Escondido, the City of Encinitas, the City of Del Mar, and the County of San Diego provided augmented data in the Carlsbad WMA in their respective jurisdictional areas.

Summary of Deliverables for Potential Critical Coarse Sediment Yield Areas

Format	Item	Description	Location
Report	Figures	"Geologic Grouping" "Potential Critical Coarse Sediment Yield Areas"	Attachment A.4
GIS	Map Group Layer Name	Potential Coarse Sediment Yield	Attachment C.1
	Map Layer Title	Geologic Grouping Land Cover Slope Category Geomorphic Landscape Unit Potential Coarse Sediment Yield Area Relative Sediment Production Potential Critical Coarse Sediment Yield Area	
	Geodatabase Feature Dataset	PotentialCoarseSedimentYield	
	Geodatabase Feature Class	GLUAnalysis PotentialCoarseSedimentYieldAreas PotentialCriticalCoarseSedimentYieldAreas	
	Geodatabase Geometry Type	Polygon	
KMZ [1]	KMZ File Name	Potential Critical Coarse Sediment Yield Areas	Attachment C.2

[1] To enhance the utilization of this data, the Geomorphic Landscape Unit Analysis is provided in both traditional GIS file format (ESRI software license purchase required) and as a Google Earth KMZ (Keyhole Markup Language/Zipped) file that can be viewed with the free download version of Google Earth (http://www.google.com/earth/).

2.4.4. Limitations for identifying potential critical coarse sediment yield areas

The resulting GIS layers were developed using regional datasets and provide a useful, rapid framework to perform screening-level analysis that is appropriate for watershed-scale planning studies. The methodology used to identify potential coarse sediment yield areas does not account for instream sediment supply and sediment production from mass failures like landslides which are difficult to estimate on a regional scale without performing extensive field investigation. This data set also does not account for potential existing impediments that may hinder delivery of coarse sediment to receiving waters or downstream locations within the watershed as this was beyond the scope of a regional study. Where more precise estimates are required for a particular site or subarea it is recommended that this analysis be augmented with site-specific analysis. It is also recognized that this regional data set is a function of the inherent data resolution and therefore may not conform to all site conditions, or does not reflect changes to particular areas that have occurred since the underlying data was developed. As such, the WMAA data for the potential critical coarse sediment yield areas should be verified in the field according to the procedures outlined in the Model BMP Design Manual and/or jurisdiction specific BMP Design Manual.

2.5. Physical Structures

The Regional MS4 Permit requires the Copermittees to identify information regarding locations of existing flood control structures and channel structures, such as stream armoring, constrictions, grade control structures, and hydromodification or flood management basins with GIS layers (maps) as output, for each WMA being analyzed for the purpose of developing watershed-specific requirements for structural BMP implementation. This study identified the physical structures using a desktop-level analysis for the stream(s) identified in Section 2.2 in compliance with this permit provision.

2.5.1. Approach for identifying physical structures

The intent of this portion of the WMAA project was to provide an initial assessment of the structures of interest for the stream(s) identified in Section 2.2. This desktop-level analysis was conducted primarily as a visual survey of aerial imagery and FEMA flood insurance study (FIS) profiles where available. The collected information was entered into a GIS layer for inclusion into the overall WMAA geodatabase containing the characterization layers required by the Regional MS4 Permit. To support overall WMA characterization, the information derived in this task provides insight into water and sediment movement through the watershed (SCCWRP, 2012), the opportunities and limitations for infrastructure retrofits and also informs efforts to identify appropriate locations for habitat or riparian area rehabilitation in relation to proximate infrastructure. Specific information regarding how the survey was performed and the attributes of the generated data is presented in Attachment A.5. Note that concrete channels, pipes/culverts, riprap or other artificial stream armoring, and basins have also been identified in the linework generated for the streams (see Section 2.2).

2.5.2. Results for identifying physical structures

The resulting GIS mapping provided in Attachment A.5 shows the spatial locations of the physical structures within the mapped stream(s).

Summary of Deliverables for Physical Structures

Format	Item	Description	Location
Report	Figure	Watershed Management Area Streams by Reach Type with Channel Structures	Attachment A.5
GIS	Map Group Layer Name	Channel Structures	Attachment C.1
	Map Layer Title	Channel Structures	
	Geodatabase Feature Dataset	ChannelStructures	
	Geodatabase Feature Class	ChannelStructures	
	Geodatabase Geometry Type	Point	
KMZ [1]	Kmz File Name	ChannelStructures	Attachment C.2

[1] To enhance the utilization of this data, the Physical Structures map is provided in both traditional GIS file format (ESRI software license purchase required) and as a Google Earth KMZ (Keyhole Markup Language/Zipped) file that can be viewed with the free download version of Google Earth (http://www.google.com/earth/).

3. Template for Candidate Project List

The Regional MS4 Permit requires each WMA to use the results from the WMA characterization to compile a list of candidate projects that could potentially be used as alternative compliance options for Priority Development Projects should an agency or jurisdiction opt to develop an alternative compliance program. Copermittees must first conclude that implementing such a candidate project would provide greater overall benefit to the watershed than requiring implementation of structural BMPs onsite prior to implementing these candidate projects as alternative compliance projects.

The Copermittees elected to identify potential candidate projects as a separate effort from this regional project, and therefore the process for identifying candidate projects is not documented in this report. Instead, this project only developed a template, in a spreadsheet format, for use by the Copermittees to compile lists of potential candidate projects. The template is intended to enhance regional consistency of the information that is gathered for candidate projects. The template spreadsheet file was distributed to the Copermittees on January 28, 2014. A table of the template components is indicated below:

Column	Primary Heading	Secondary Heading	Guidance for Completing the Project List
A	Project Identifier	-	Unique identifier for the project.
B	Watershed Management Area	-	Dropdown menu to select the watershed management area the project is located in
C	Hydrologic Area (HA)	-	Dropdown menu to select the hydrologic area the project is located in Select a WMA in column B for HA (Column C) dropdown menu to activate.
D	Hydrologic Subarea (HSA)	-	Dropdown menu to select the hydrologic subarea the project is located in. Select a HA in column C for HSA (Column D) dropdown menu to activate.
E	Jurisdiction	-	Dropdown menu to select the jurisdiction the project is located in. Select a HSA in column D for Jurisdiction (Column E) dropdown menu to activate.
F	Project Name	-	Indicate the name of the project.
G	Ownership	Type	Dropdown menu to select if the project is a public project, private project, or public-private partnership.
H	Ownership	Ownership Information	List the details for the owner.
I	Project Location	Address	List the address of the project site.
J	Project Location	APN	List the APN of the parcel.
K	Project Location	Latitude	List the latitude of the project site.
L	Project Location	Longitude	List the longitude of the project site.
M	Project Origination/ Originator	Name	List the name of the report/organization/individual that provided the idea for the project. Potential origination sources: WQIP, WMAA, JURMPs, WURMPs, CLRPs, IRWM, MSCP, MHPA, Other.

Column	Primary Heading	Secondary Heading	Guidance for Completing the Project List
N	Project Origination/ Originator	Contact Information	Link or report title if the proposed project is from a report [or] contact information if from an organization/individual.
O	Project Category	-	Drop Down menu to select the project category; In addition to the 6 project categories explicitly listed in the Regional MS4 Permit, the drop down menu also has a category "Other project types allowed by the MS4 Permit". Example for "Other" project types are agency CIP programs such as Green Streets, LID conversions (medians, parks), agency filter installation, etc.
P	Specific Project Type	-	List the subcategory of the project; for example, list Regional BMP type (i.e. infiltration basin, wetland, etc.).
Q	Potential Pollutant	-	Identify the potential pollutant(s) that can be treated by the proposed project.
R	Project Size & Parameters	Contributing Drainage Area (acres)	List the contributing drainage area to the project.
S	Project Size & Parameters	Parcel Size (acres)	List the size of the parcel the project is located on.
T	Project Size & Parameters	Project Footprint (acres)	List the size of the project footprint.
U	Project Size & Parameters	Parameters (with units as necessary)	Parameters needed to quantify benefits from the project; i.e. for an infiltration basin, list the water quality volume, long-term infiltration rate, depth of the basin, etc.
V	Regulatory Requirement	-	Indicate if the project is proposed to meet particular regulatory requirement such as TMDL, etc.
W	Project Timeline	-	Indicate if a project must be implemented by certain date to meet a grant deadline or other time commitment.
X	Other Notes	-	List any other relevant notes; for example, when retrofitting existing infrastructure project category is selected, input parameters needed to quantify benefits from existing infrastructure into this column as these will be needed to estimate additional benefits that can be used for alternative compliance. If N/A is selected in any dropdown menus, add additional explanation in here

4. Hydromodification Management Applicability/Exemptions

Hydromodification, which is caused by both altered storm water flow and altered sediment flow regimes, is largely responsible for degradation of creeks, streams, and associated habitats in the San Diego Region. The purpose of the hydromodification management requirements in the Regional MS4 Permit is to maintain or restore more natural hydrologic flow regimes to prevent accelerated, unnatural erosion in downstream receiving waters.

In some cases, priority development projects may be exempt from hydromodification management requirements if the project site discharges runoff to receiving waters that are not susceptible to erosion (e.g., a lake, lagoon, bay, or the Pacific Ocean) either directly or via hardened systems including concrete-lined channels or existing (non-erodible) underground storm drain systems.

The intent of this Section is to provide mapping of areas exempt from hydromodification management requirements, and provide supporting technical analyses for exemptions that are recommended by the WMAA.

For discharges to lagoons that may qualify for exemption from hydromodification, a study was performed using criteria from the 2013 MS4 Permit.

4.1. Additional Analysis for Hydromodification Management Exemptions

This section documents additional analysis performed to evaluate the following exemptions that were originally part of the approved 2011 Final Hydromodification Management Plan but were not included in the current Regional MS4 Permit and provides recommendation based on the results from the analysis performed if these exemptions should be reinstated through WMAA:

- Exempt River Reaches
- Stabilized Conveyance Systems Draining to Exempt Water Bodies
- Highly Impervious Watersheds and Urban Infill and
- Tidally Influenced Lagoons

4.1.1. Exempt River Reaches

There are no river reaches currently recommended for exemption from hydromodification management requirements in the Carlsbad WMA. Potential river reach exemptions may be studied using the recommended approach documented in the Regional WMAA. Refer to the Regional WMAA for the criteria and an example exemption studies that were prepared for the five river reaches included in the San Diego County Final HMP dated March 2011.

4.1.2. Stabilized Conveyance Systems Draining to Exempt Water Bodies

There are no stabilized conveyance systems currently recommended for exemption from hydromodification management requirements in the Carlsbad WMA. If engineered conveyance systems that are stabilized with materials other than concrete, such as riprap, turf reinforcement mat, or vegetation, including rehabilitated stream systems, are identified as potential candidates for exemption, they may be studied and may be recommended exempt if they meet specific criteria presented in the Regional WMAA for this exemption. Refer to the Regional WMAA for the criteria and an example study that was prepared for Forester Creek in the San Diego River WMA.

4.1.3. Highly Impervious/Highly Urbanized Watersheds and Urban Infill

Based on evaluation of the highly impervious/highly urbanized watershed and urban infill exemptions presented in the March 2011 Final HMP, and comparison with more recent research prepared for the Ventura County Hydromodification Control Plan (Ventura County HCP) (Final Draft dated September 2013), resurrection of these exemptions from the March 2011 Final HMP was not recommended by the Regional WMAA. The research prepared in support of the Ventura County HCP determined lower thresholds of additional impervious area (ranging from 0.44% to 1.65%) than the limit presented in the San Diego County Final HMP dated March 2011 (3%). No areas within the Carlsbad WMA are currently recommended for highly impervious/highly urbanized watershed or urban infill exemption.

4.1.4. Lagoon Exemption

4.1.4.1. History

The 2013 MS4 Permit, provides the following exemption from hydromodification management requirements:

> *Each Copermittee has the discretion to exempt a Priority Development Project from hydromodification management BMP performance requirements of Provisions E.3.c.(2) where the project discharges water runoff to:*
>
> *i) Existing underground storm drains discharging directly to water storage reservoirs, lakes, enclosed embayments, or the Pacific Ocean.*
>
> *ii) Conveyance channels whose bed and bank are concrete lined all the way from the point of discharge to water storage reservoirs, lakes, enclosed embayments, or the Pacific Ocean;*

The Lagoons (*embayments*) are considered exempt water bodies and, per the 2013 MS4 Permit, in order to demonstrate exemption from hydromodification effects, certain areas with hardened (non-erodible) systems tributary to the exempt water bodies and with potential 'direct discharges' to the

Lagoons, may be appropriate for an exemption from hydromodification. If findings can be made, then these areas may be considered exempt from hydromodification. This effort, however, may be identified in the optional WMAA incorporated into the WQIP. Therefore, a study was commissioned to evaluate select drainage areas that could meet the requirements of hydromodification exemptions per the 2013 MS4 Permit.

4.1.4.2. Research and Results

Discharges to lagoons may be considered exempt from hydromodification based on the 2013 MS4 Permit, provided sufficient supporting information can be established to ensure there is no erosion potential within the MS4 as described above.

In 2013 the City of Carlsbad's Land Development Engineering Division approved a study that examined seven major drainage areas contributing to three lagoons within the City of Carlsbad (Buena Vista, Agua Hedionda, and Batiquitos Lagoon). At the time, this study satisfied the 2007 MS4 Permit requirements. However, this study was updated in 2015 to address more specific provisions in the 2013 MS4 Permit. Although certain areas did, not all drainage areas qualified for HMP exemption. The study summarizes why they did not, or efforts (improvements) that would allow those areas to be considered exempt in the future.

The updated study is titled, "Hydromodification Exemption Analyses for Select Carlsbad Watersheds," prepared by Chang Consultants, dated September 17, 2015. Each of the seven major drainage areas includes a continuous network of non-erodible storm water conveyance facilities that serves the drainage area. The study identifies certain areas where HMP exemptions are applicable and provides supporting information on the hardened (non-erodible) facilities, 10-year event capacity, and discharge/outlet conditions to the lagoons. A copy of the study text and hydromodification exemption maps is provided in Attachment B.1.4. The study makes the following conclusions regarding the lagoons and qualifying systems draining into each lagoon:

- Agua Hedionda Lagoon and Batiquitos Lagoon are considered exempt water bodies as described in the 2013 MS4 Permit. Certain areas draining to the lagoons were studied. From record research and performing hydrologic and hydraulic analyses, the study shows that the hardened (non-erodible) drainage facilities convey the 10-year flows to the lagoon outlets. From site visits and record research, each of the outlets into these two lagoons are shown to have proper energy dissipation and each outlet also was confirmed to be within the 100-year flood limits. For those non-erodible systems with outlets qualifying as ‘direct discharges’ to the lagoons, those areas are considered exempt from hydromodification requirements.
- Buena Vista Lagoon” is considered an exempt water body as described in the 2013 MS4 Permit. Certain areas draining to the lagoon was studied. From record research and performing hydrologic and hydraulic analyses, the study shows that the hardened (non-erodible) drainage facilities convey the 10-year flows to the lagoon outlets. From site visits and record research, each of the outlets into the lagoon is shown to have proper energy dissipation and each outlet also was confirmed to be within the 100-year flood limits. For those non-erodible systems with outlets qualifying as ‘direct discharges’ to the lagoons, those areas are considered exempt from hydromodification requirements.

4.1.4.3. Recommendation

Storm water conveyance systems and their respective drainage areas that have been identified in the study titled, "Hydromodification Exemption Analyses for Select Carlsbad Watersheds," prepared by Chang Consultants, dated September 17, 2015, should be exempt from hydromodification management requirements. The study, approved by the City of Carlsbad, has demonstrated that the areas are appropriate for an exemption. The storm water conveyance systems have been identified as "recommended for exemption" on the exhibits in Attachment C.1 of this report titled, "Water Bodies and Systems Exempt or Potentially Exempt from Hydromodification Management Requirements." These storm water conveyance systems and their respective drainage areas and the September 2015 study should be adopted into the Carlsbad Watershed Management Area Analysis.

5. Conclusions

5.1. Watershed Management Area Characterization

The WMA Characterization data was developed using available regional data to further understand the macro-scale watershed characteristics and processes in the Carlsbad WMA. The Regional MS4 Permit allows for flexibility in complying with land development requirements when using the information developed in the WMAA to improve water quality planning and implementation associated with land development. This dataset will assist with identifying the opportunities and constraints for watershed-scale projects and management decisions based (as opposed to piecemeal project identification) and provides Copermittees the ability to exercise the option to create an alternative compliance program that offers the opportunity to develop watershed-specific alternatives to universal onsite structural BMP implementation. The characterization data includes:

Characterization Data	Utilization Potential
Dominant Hydrologic Process: • Overland flow • Infiltration • Interflow	• Identify areas for enhanced infiltration or collection of storm water for treatment • Implement management measures that correspond to pre-development conditions – promotes long-term channel stability and health • Increases understanding of the natural functioning of the watershed and what has been (or is at risk of being) altered by urbanization.
Stream Characterization: • Reach type • Bed material • Bank material • Hydrographic category • Channel Structures	• Preliminary dataset that can be used to conduct stream power evaluations • Identify channel systems for preservation or restoration • Identification of appropriate space for channel processes to occur (e.g., flood plain connectivity) • Insight to sensitivity of receiving stream reach • Indicates the features within channels that affect water and sediment movement through the watershed

Characterization Data	Utilization Potential
Land Use: • Existing • Future	• Foresight (identifies relative risks, opportunities, or constraints) in comparing future to existing land uses, i.e., areas that may be more/less vulnerable to adverse impacts to changes in storm water runoff associated with development • Encourage infill development
Potential Critical Coarse Sediment Yield Areas	• Preservation of areas or function that contributes critical sediment within the watershed to stream armoring/stability • Assist with identifying potentially susceptible stream reaches that require uninterrupted coarse sediment supplies to remain stable • Dual goal of open space conservation

Regarding the identification of the potential critical coarse sediment yield areas in the WMAA using readily available regional datasets, it is anticipated that when more precise estimates for potential critical coarse sediment yield areas are required for a particular site or subarea that this regional study will be augmented with site-specific analysis. Development projects must avoid critical sediment yield areas or implement measures that allow critical coarse sediment to be discharged to receiving waters, such that there is no net impact to the receiving water to meet the requirements of the Regional MS4 permit. As such, projects should consult the Model BMP Design Manual and/or jurisdiction specific BMP Design manual for options to meet the Regional MS4 Permit requirements. It is anticipated that the data will not be static but will be enhanced over time through future studies or field assessments that will refine what is currently a macro-level data set.

5.2. Template for Candidate Project List

It is anticipated the Copermittees that elect to develop alternative compliance programs will conduct a separate exercise to nominate potential candidate projects for inclusion into the WQIPs using the template developed for this project.

5.3. Hydromodification Management Exemptions

Attachment B.2 presents hydromodification management applicability/exemption mapping for the Carlsbad WMA. The mapping includes receiving waters that are exempt based on the Regional MS4 Permit or recommended exempt based on studies.

Receiving waters that are **exempt** based on the Regional MS4 Permit include:

- The Pacific Ocean
- Lakes and Reservoirs
- Existing underground storm drains or concrete-lined channels draining directly to the ocean

Receiving waters or conveyance systems that are **recommended exempt** in the Carlsbad WMA based on studies that were provided to the Regional WMAA for this purpose include:

- Buena Vista Lagoon
- Existing underground storm drains or concrete-lined channels discharging directly to Buena Vista Lagoon, and localized outfalls to Agua Hedionda Lagoon and Batiquitos Lagoon. These systems were identified based on the City of Carlsbad's study of Buena Vista Lagoon, Agua Hedionda Lagoon and Batiquitos Lagoon. These systems may not represent all discharges to the above-listed bodies. Additional systems may be considered exempt if there is no evidence of erosion at the outfall of the conveyance system, the resultant effects on lagoon-system biology have been evaluated for tidally-influenced lagoon outfalls, and any other criteria determined by the local jurisdiction.

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Carlsbad
Watershed Management Area Analysis
ATTACHMENTS

Lake Henshaw

October 3, 2014

Prepared for:
San Diego County Copermittees

Prepared by:

Geosyntec consultants

RICK Engineering Company

ATTACHMENT A

WATERSHED MANAGEMENT AREA CHARACTERIZATION

ATTACHMENT A.1

DOMINANT HYDROLOGICAL PROCESS

A.1 Dominant Hydrological Process

Table A.1.1: Runoff Coefficients versus Land Use, Hydrologic Soil Group (A, B, C, D), and Slope Range

	A			B			C			D		
Land Use	0–2%	2–6%	6%+	0–2%	2–6%	6%+	0–2%	2–6%	6%+	0–2%	2–6%	6%+
Cultivated land	0.08[a]	0.13	0.16	0.11	0.15	0.21	0.14	0.19	0.26	0.18	0.23	0.31
	0.14[b]	0.18	0.22	0.16	0.21	0.28	0.20	0.25	0.34	0.24	0.29	0.41
Pasture	0.12	0.20	0.30	0.18	0.28	0.37	0.24	0.34	0.44	0.30	0.40	0.50
	0.15	0.25	0.37	0.23	0.34	0.45	0.30	0.42	0.52	0.37	0.50	0.62
Meadow	0.10	0.16	0.25	0.14	0.22	0.30	0.20	0.28	0.36	0.24	0.30	0.40
	0.14	0.22	0.30	0.20	0.28	0.37	0.26	0.35	0.44	0.30	0.40	0.50
Forest	0.05	0.08	0.11	0.08	0.11	0.14	0.10	0.13	0.16	0.12	0.16	0.20
	0.08	0.11	0.14	0.10	0.14	0.18	0.12	0.16	0.20	0.15	0.20	0.25
Residential lot size 1/8 acre	0.25	0.28	0.31	0.27	0.30	0.35	0.30	0.33	0.38	0.33	0.36	0.42
	0.33	0.37	0.40	0.35	0.39	0.44	0.38	0.42	0.49	0.41	0.45	0.54
Residential lot size 1/4 acre	0.22	0.26	0.29	0.24	0.29	0.33	0.27	0.31	0.36	0.30	0.34	0.40
	0.30	0.34	0.37	0.33	0.37	0.42	0.36	0.40	0.47	0.38	0.42	0.52
Residential lot size 1/3 acre	0.19	0.23	0.26	0.22	0.26	0.30	0.25	0.29	0.34	0.28	0.32	0.39
	0.28	0.32	0.35	0.30	0.35	0.39	0.33	0.38	0.45	0.36	0.40	0.50
Residential lot size 1/2 acre	0.16	0.20	0.24	0.19	0.23	0.28	0.22	0.27	0.32	0.26	0.30	0.37
	0.25	0.29	0.32	0.28	0.32	0.36	0.31	0.35	0.42	0.34	0.38	0.48
Residential lot size 1 acre	0.14	0.19	0.22	0.17	0.21	0.26	0.20	0.25	0.31	0.24	0.29	0.35
	0.22	0.26	0.29	0.24	0.28	0.34	0.28	0.32	0.40	0.31	0.35	0.46
Industrial	0.67	0.68	0.68	0.68	0.68	0.69	0.68	0.69	0.69	0.69	0.69	0.70
	0.85	0.85	0.86	0.85	0.86	0.86	0.86	0.86	0.87	0.86	0.86	0.88
Commercial	0.71	0.71	0.72	0.71	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
	0.88	0.88	0.89	0.89	0.89	0.89	0.89	0.89	0.90	0.89	0.89	0.90
Streets	0.70	0.71	0.72	0.71	0.72	0.74	0.72	0.73	0.76	0.73	0.75	0.78
	0.76	0.77	0.79	0.80	0.82	0.84	0.84	0.85	0.89	0.89	0.91	0.95
Open space	0.05	0.10	0.14	0.08	0.13	0.19	0.12	0.17	0.24	0.16	0.21	0.28
	0.11	0.16	0.20	0.14	0.19	0.26	0.18	0.23	0.32	0.22	0.27	0.39
Parking	0.85	0.86	0.87	0.85	0.86	0.87	0.85	0.86	0.87	0.85	0.86	0.87
	0.95	0.96	0.97	0.95	0.96	0.97	0.95	0.96	0.97	0.95	0.96	0.97

[a] Runoff coefficients for storm recurrence intervals less than 25 years.

[b] Runoff coefficients for storm recurrence intervals of 25 years or longer.

Source: Table 7-9 in *Hydrologic Analysis and Design* (McCuen, 2005)

Table A.1.2: Land Cover Grouping

Id	SanGIS Legend	SanGIS Grouping	Land Cover Grouping
1	42000 Valley and Foothill Grassland	Grasslands, Vernal Pools, Meadows, and Other Herb Communities	Agricultural/Grass
2	42100 Native Grassland		Agricultural/Grass
3	42110 Valley Needlegrass Grassland		Agricultural/Grass
4	42120 Valley Sacaton Grassland		Agricultural/Grass

Id	SanGIS Legend	SanGIS Grouping	Land Cover Grouping
5	42200 Non-Native Grassland	Grasslands, Vernal Pools, Meadows, and Other Herb Communities	Agricultural/Grass
6	42300 Wildflower Field		Agriculture/Grass
7	42400 Foothill/Mountain Perennial Grassland		Agriculture/Grass
8	42470 Transmontane Dropseed Grassland		Agriculture/Grass
9	45000 Meadow and Seep		Agriculture/Grass
10	45100 Montane Meadow		Agriculture/Grass
11	45110 Wet Montane Meadow		Agriculture/Grass
12	45120 Dry Montane Meadows		Agriculture/Grass
13	45300 Alkali Meadows and Seeps		Agriculture/Grass
14	45320 Alkali Seep		Agriculture/Grass
15	45400 Freshwater Seep		Agriculture/Grass
16	46000 Alkali Playa Community		Agriculture/Grass
17	46100 Badlands/Mudhill Forbs		Agriculture/Grass
18	Non-Native Grassland		Agriculture/Grass
19	18000 General Agriculture	Non-Native Vegetation, Developed Areas, or Unvegetated Habitat	Agriculture/Grass
20	18100 Orchards and Vineyards		Agriculture/Grass
21	18200 Intensive Agriculture		Agriculture/Grass
22	18200 Intensive Agriculture - Dairies, Nurseries, Chicken Ranches		Agriculture/Grass
23	18300 Extensive Agriculture - Field/Pasture, Row Crops		Agriculture/Grass
24	18310 Field/Pasture		Agriculture/Grass
25	18310 Pasture		Agriculture/Grass
26	18320 Row Crops		Agriculture/Grass
27	12000 Urban/Developed		Developed
28	12000 Urban/Develped		Developed
29	81100 Mixed Evergreen Forest	Forest	Forest
30	81300 Oak Forest		Forest
31	81310 Coast Live Oak Forest		Forest
32	81320 Canyon Live Oak Forest		Forest
33	81340 Black Oak Forest		Forest
34	83140 Torrey Pine Forest		Forest
35	83230 Southern Interior Cypress Forest		Forest
36	84000 Lower Montane Coniferous Forest		Forest
37	84100 Coast Range, Klamath and Peninsular Coniferous Forest		Forest

Id	SanGIS Legend	SanGIS Grouping	Land Cover Grouping
38	84140 Coulter Pine Forest	Forest	Forest
39	84150 Bigcone Spruce (Bigcone Douglas Fir)-Canyon Oak Forest		Forest
40	84230 Sierran Mixed Coniferous Forest		Forest
41	84500 Mixed Oak/Coniferous/Bigcone/Coulter		Forest
42	85100 Jeffrey Pine Forest		Forest
43	11100 Eucalyptus Woodland	Non-Native Vegetation, Developed Areas, or Unvegetated Habitat	Forest
44	60000 RIPARIAN AND BOTTOMLAND HABITAT	Riparian and Bottomland Habitat	Forest
45	61000 Riparian Forests		Forest
46	61300 Southern Riparian Forest		Forest
47	61310 Southern Coast Live Oak Riparian Forest		Forest
48	61320 Southern Arroyo Willow Riparian Forest		Forest
49	61330 Southern Cottonwood-willow Riparian Forest		Forest
50	61510 White Alder Riparian Forest		Forest
51	61810 Sonoran Cottonwood-willow Riparian Forest		Forest
52	61820 Mesquite Bosque		Forest
53	62000 Riparian Woodlands		Forest
54	62200 Desert Dry Wash Woodland		Forest
55	62300 Desert Fan Palm Oasis Woodland		Forest
56	62400 Southern Sycamore-alder Riparian Woodland		Forest
57	70000 WOODLAND	Woodland	Forest
58	71000 Cismontane Woodland		Forest
59	71100 Oak Woodland		Forest
60	71120 Black Oak Woodland		Forest
61	71160 Coast Live Oak Woodland		Forest
62	71161 Open Coast Live Oak Woodland		Forest
63	71162 Dense Coast Live Oak Woodland		Forest
64	71162 Dense Coast Love Oak Woodland		Forest

Id	SanGIS Legend	SanGIS Grouping	Land Cover Grouping
65	71180 Engelmann Oak Woodland	Woodland	Forest
66	71181 Open Engelmann Oak Woodland		Forest
67	71182 Dense Engelmann Oak Woodland		Forest
68	72300 Peninsular Pinon and Juniper Woodlands		Forest
69	72310 Peninsular Pinon Woodland		Forest
70	72320 Peninsular Juniper Woodland and Scrub		Forest
71	75100 Elephant Tree Woodland		Forest
72	77000 Mixed Oak Woodland		Forest
73	78000 Undifferentiated Open Woodland		Forest
74	79000 Undifferentiated Dense Woodland		Forest
75	Engelmann Oak Woodland		Forest
76	52120 Southern Coastal Salt Marsh	Bog and Marsh	Other
77	52300 Alkali Marsh		Other
78	52310 Cismontane Alkali Marsh		Other
79	52400 Freshwater Marsh		Other
80	52410 Coastal and Valley Freshwater Marsh		Other
81	52420 Transmontane Freshwater Marsh		Other
82	52440 Emergent Wetland		Other
83	44000 Vernal Pool	Grasslands, Vernal Pools, Meadows, and Other Herb Communities	Other
84	44320 San Diego Mesa Vernal Pool		Other
85	44322 San Diego Mesa Claypan Vernal Pool (southern mesas)		Other
86	13100 Open Water	Non-Native Vegetation, Developed Areas, or Unvegetated Habitat	Other
87	13110 Marine		Other
88	13111 Subtidal		Other
89	13112 Intertidal		Other
90	13121 Deep Bay		Other
91	13122 Intermediate Bay		Other
92	13123 Shallow Bay		Other
93	13130 Estuarine		Other
94	13131 Subtidal		Other
95	13133 Brackishwater		Other

Id	SanGIS Legend	SanGIS Grouping	Land Cover Grouping
96	13140 Freshwater	Non-Native Vegetation, Developed Areas, or Unvegetated Habitat	Other
97	13200 Non-Vegetated Channel, Floodway, Lakeshore Fringe		Other
98	13300 Saltpan/Mudflats		Other
99	13400 Beach		Other
100	21230 Southern Foredunes	Dune Community	Scrub/Shrub
101	22100 Active Desert Dunes		Scrub/Shrub
102	22300 Stabilized and Partially-Stabilized Desert Sand Field		Scrub/Shrub
103	24000 Stabilized Alkaline Dunes		Scrub/Shrub
104	29000 ACACIA SCRUB		Scrub/Shrub
105	63000 Riparian Scrubs	Riparian and Bottomland Habitat	Scrub/Shrub
106	63300 Southern Riparian Scrub		Scrub/Shrub
107	63310 Mule Fat Scrub		Scrub/Shrub
108	63310 Mulefat Scrub		Scrub/Shrub
109	63320 Southern Willow Scrub		Scrub/Shrub
110	63321 Arundo donnax Dominant/Southern Willow Scrub		Scrub/Shrub
111	63330 Southern Riparian Scrub		Scrub/Shrub
112	63400 Great Valley Scrub		Scrub/Shrub
113	63410 Great Valley Willow Scrub		Scrub/Shrub
114	63800 Colorado Riparian Scrub		Scrub/Shrub
115	63810 Tamarisk Scrub		Scrub/Shrub
116	63820 Arrowweed Scrub		Scrub/Shrub
117	31200 Southern Coastal Bluff Scrub	Scrub and Chaparral	Scrub/Shrub
118	32000 Coastal Scrub		Scrub/Shrub
119	32400 Maritime Succulent Scrub		Scrub/Shrub
120	32500 Diegan Coastal Sage Scrub		Scrub/Shrub
121	32510 Coastal form		Scrub/Shrub
122	32520 Inland form (> 1,000 ft. elevation)		Scrub/Shrub
123	32700 Riversidian Sage Scrub		Scrub/Shrub
124	32710 Riversidian Upland Sage Scrub		Scrub/Shrub
125	32720 Alluvial Fan Scrub		Scrub/Shrub
126	33000 Sonoran Desert Scrub		Scrub/Shrub
127	33100 Sonoran Creosote Bush Scrub		Scrub/Shrub
128	33200 Sonoran Desert Mixed Scrub		Scrub/Shrub
129	33210 Sonoran Mixed Woody Scrub		Scrub/Shrub

Id	SanGIS Legend	SanGIS Grouping	Land Cover Grouping
130	33220 Sonoran Mixed Woody and Succulent Scrub	Scrub and Chaparral	Scrub/Shrub
131	33230 Sonoran Wash Scrub		Scrub/Shrub
132	33300 Colorado Desert Wash Scrub		Scrub/Shrub
133	33600 Encelia Scrub		Scrub/Shrub
134	34000 Mojavean Desert Scrub		Scrub/Shrub
135	34300 Blackbush Scrub		Scrub/Shrub
136	35000 Great Basin Scrub		Scrub/Shrub
137	35200 Sagebrush Scrub		Scrub/Shrub
138	35210 Big Sagebrush Scrub		Scrub/Shrub
139	35210 Sagebrush Scrub		Scrub/Shrub
140	36110 Desert Saltbush Scrub		Scrub/Shrub
141	36120 Desert Sink Scrub		Scrub/Shrub
142	37000 Chaparral		Scrub/Shrub
143	37120 Southern Mixed Chaparral		Scrub/Shrub
144	37120 Southern Mixed Chapparal		Scrub/Shrub
145	37121 Granitic Southern Mixed Chaparral		Scrub/Shrub
146	37121 Southern Mixed Chaparral		Scrub/Shrub
147	37122 Mafic Southern Mixed Chaparral		Scrub/Shrub
148	37130 Northern Mixed Chaparral		Scrub/Shrub
149	37131 Granitic Northern Mixed Chaparral		Scrub/Shrub
150	37132 Mafic Northern Mixed Chaparral		Scrub/Shrub
151	37200 Chamise Chaparral		Scrub/Shrub
152	37210 Granitic Chamise Chaparral		Scrub/Shrub
153	37220 Mafic Chamise Chaparral		Scrub/Shrub
154	37300 Red Shank Chaparral		Scrub/Shrub
155	37400 Semi-Desert Chaparral		Scrub/Shrub
156	37500 Montane Chaparral		Scrub/Shrub
157	37510 Mixed Montane Chaparral		Scrub/Shrub
158	37520 Montane Manzanita Chaparral		Scrub/Shrub
159	37530 Montane Ceanothus Chaparral		Scrub/Shrub
160	37540 Montane Scrub Oak Chaparral		Scrub/Shrub
161	37800 Upper Sonoran Ceanothus Chaparral		Scrub/Shrub
162	37830 Ceanothus crassifolius Chaparral		Scrub/Shrub
163	37900 Scrub Oak Chaparral		Scrub/Shrub
164	37A00 Interior Live Oak Chaparral		Scrub/Shrub

Id	SanGIS Legend	SanGIS Grouping	Land Cover Grouping
165	37C30 Southern Maritime Chaparral	Scrub and Chaparral	Scrub/Shrub
166	37G00 Coastal Sage-Chaparral Scrub		Scrub/Shrub
167	37K00 Flat-topped Buckwheat		Scrub/Shrub
168	39000 Upper Sonoran Subshrub Scrub		Scrub/Shrub
169	Diegan Coastal Sage Scrub		Scrub/Shrub
170	Granitic Northern Mixed Chaparral		Scrub/Shrub
171	Southern Mixed Chaparral		Scrub/Shrub
172	11000 Non-Native Vegetation	Non-Native Vegetation, Developed Areas, or Unvegetated Habitat	Unknown
173	11000 Non-Native VegetionVegetation		Unknown
174	11200 Disturbed Wetland		Unknown
175	11300 Disturbed Habitat		Unknown
176	13000 Unvegetated Habitat		Unknown
177	Disturbed Habitat		Unknown

Table A.1.3: Related Land Cover and Land Use Categories

Land Cover per San Diego County	Land Use per Table A.1.1
Agriculture/Grass	Meadow
Forest	Forest
Scrub/Shrub	Average (Meadow, Forest)
Unknown/Other	Meadow

Table A.1.4: Applicable Hydrologic Response Unit Calculations

Land Cover	Soil	Gradient	Runoff Coeff.	ET Coeff.	Infiltration Coeff.	Runoff/ Infiltration Ratio	Hydrologic Process Designation
Agriculture/Grass	A	0-2%	0.10	0.60	0.30	0.33	I
Agriculture/Grass	A	2-6%	0.16	0.60	0.24	0.67	U
Agriculture/Grass	A	6-10%	0.25	0.60	0.15	1.67	O
Agriculture/Grass	B	0-2%	0.14	0.60	0.26	0.54	I
Agriculture/Grass	B	2-6%	0.22	0.60	0.18	1.22	U
Agriculture/Grass	B	6-10%	0.30	0.60	0.10	3.00	O
Agriculture/Grass	C	0-2%	0.20	0.60	0.20	1.00	U
Agriculture/Grass	C	2-6%	0.28	0.60	0.12	2.33	O
Agriculture/Grass	C	6-10%	0.36	0.60	0.04	9.00	O
Agriculture/Grass	D	0-2%	0.24	0.60	0.16	1.50	U
Agriculture/Grass	D	2-6%	0.30	0.60	0.10	3.00	O
Agriculture/Grass	D	6-10%	0.40	0.60	0.00	infinite	O

Land Cover	Soil	Gradient	Runoff Coeff.	ET Coeff.	Infiltration Coeff.	Runoff/ Infiltration Ratio	Hydrologic Process Designation
Forest	A	0-2%	0.05	0.80	0.15	0.33	I
Forest	A	2-6%	0.08	0.80	0.12	0.67	U
Forest	A	6-10%	0.11	0.80	0.09	1.22	U
Forest	B	0-2%	0.08	0.80	0.12	0.67	U
Forest	B	2-6%	0.11	0.80	0.09	1.22	U
Forest	B	6-10%	0.14	0.80	0.06	2.33	O
Forest	C	0-2%	0.10	0.80	0.10	1.00	U
Forest	C	2-6%	0.13	0.80	0.07	1.86	O
Forest	C	6-10%	0.16	0.80	0.04	4.00	O
Forest	D	0-2%	0.12	0.80	0.08	1.50	U
Forest	D	2-6%	0.16	0.80	0.04	4.00	O
Forest	D	6-10%	0.20	0.80	0.00	infinite	O
Scrub/Shrub	A	0-2%	0.08	0.70	0.23	0.33	I
Scrub/Shrub	A	2-6%	0.12	0.70	0.18	0.67	U
Scrub/Shrub	A	6-10%	0.18	0.70	0.12	1.50	U
Scrub/Shrub	B	0-2%	0.11	0.70	0.19	0.58	I
Scrub/Shrub	B	2-6%	0.17	0.70	0.14	1.22	U
Scrub/Shrub	B	6-10%	0.22	0.70	0.08	2.75	O
Scrub/Shrub	C	0-2%	0.15	0.70	0.15	1.00	U
Scrub/Shrub	C	2-6%	0.21	0.70	0.10	2.16	O
Scrub/Shrub	C	6-10%	0.26	0.70	0.04	6.50	O
Scrub/Shrub	D	0-2%	0.19	0.70	0.12	1.50	U
Scrub/Shrub	D	2-6%	0.23	0.70	0.07	3.29	O
Scrub/Shrub	D	6-10%	0.30	0.70	0.00	infinite	O

Hydrologic Process Designation: I = Interflow; O = Overland Flow; U = Uncertain

Table A.1.5: Hydrologic Response Unit Designations

Land Cover	Slope	Soil Type A	Soil Type B	Soil Type C	Soil Type D	Soil Type Other (fill/water)
Agriculture/ Grass/Unknown/ Other	0-2%	I	I	U	U	U
	2-6%	U	U	O	O	U
	6-10%	O	O	O	O	O
	>10%	O	O	O	O	O
Developed	0-2%	O	O	O	O	O
	2-6%	O	O	O	O	O
	6-10%	O	O	O	O	O
	>10%	O	O	O	O	O
Forest	0-2%	I	U	U	U	U
	2-6%	U	U	O	O	U
	6-10%	U	O	O	O	U
	>10%	O	O	O	O	O
Scrub/Shrub	0-2%	I	I	U	U	U
	2-6%	U	U	O	O	U
	6-10%	U	O	O	O	U
	>10%	O	O	O	O	O

Hydrologic Process Designation: I = Interflow; O = Overland Flow; U = Uncertain

Exhibit Showing Dominant Hydrologic Processes

Carlsbad Watershed - HU 904.00, 211 mi2

Exhibit Date: Sept. 8, 2014

Geosyntec consultants

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ATTACHMENT A.2

STREAM CHARACTERIZATION

Watershed Management Area Streams

Carlsbad Watershed - HU 904.00, 211 mi2

Exhibit Date: Sept. 8, 2014

Geosyntec consultants

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Watershed Management Area Streams by Hydrographic Category

Carlsbad Watershed - HU 904.00, 211 mi2

Exhibit Date: Sept. 8, 2014

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Watershed Management Area Streams by Bed Material

Carlsbad Watershed - HU 904.00, 211 mi2

Exhibit Date: Sept. 8, 2014

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Watershed Management Area Streams by Geologic Group

Carlsbad Watershed - HU 904.00, 211 mi2

Exhibit Date: Sept. 8, 2014

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Watershed Management Area Streams by Reach Type

Carlsbad Watershed - HU 904.00, 211 mi2

Exhibit Date: Sept. 8, 2014

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ATTACHMENT A.3
LAND USES

Existing Land Use

Carlsbad Watershed - HU 904.00, 211 mi2

Exhibit Date: Sept. 8, 2014

Miles 0 25 50 100 150

NORTH

Planned Land Use

Carlsbad Watershed - HU 904.00, 211 mi2

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Developable Land

Carlsbad Watershed - HU 904.00, 211 mi2

Exhibit Date: Sept. 8, 2014

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Redevelopment and Infill Areas

Carlsbad Watershed - HU 904.00, 211 mi2

Exhibit Date: Sept. 8, 2014

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ATTACHMENT A.4

POTENTIAL COARSE SEDIMENT YIELD AREAS

A.4.1 Geology Grouping

Geologic grouping was based on the mapped geologic unit as determined by published geologic mapping information. The following describes the methodology utilized to determine bedrock or sedimentary characteristics, anticipated grain size, and suitability for infiltration. A complete list of the various geologic maps used in this evaluation is listed in Chapter 6.

Due to the various mapped scales of the published data and differing mapped unit names, the geologic units were initially compiled into similar categories where possible. For example, the Lindavista Formation is mapped as unit Ql on geologic maps at a scale of 1:24,000 but correlates to the same unit Qvop8 on geologic maps at a scale of 1:100,000. Following the compilation of geologic unit names, the units were differentiated between crystalline bedrock and sedimentary formations based on geologic characterization and material behavior. The Point Loma Formation for example, is a Cretaceous-age sandstone, but it was classified as a “coarse bedrock” unit due to its indurated and resistant nature.

For each site location, the predominant geologic units were then described as “coarse” or “fine” based on typical weathering characteristics of the bedrock units, or primary grain size of the sedimentary units. For example, granodiorite or tonalite crystalline rock typically weathers to a coarse material such as a silty sand and therefore was classified as “coarse,” compared to a gabbro which generally weathers to a sandy clay and was characterized as “fine.” Sedimentary formations can be more variable, such as the Mission Valley Formation. In this case, the Mission Valley Formation was characterized as “coarse” since the unit is predominantly comprised of sandstone even if it does contain localities of siltstone and claystone within the unit.

To further characterize the sedimentary formations, these units were evaluated for suitability of infiltration. Since no field investigations were performed for this evaluation to determine permeability, the differentiation between impermeable and permeable were based on the age of the geologic unit with the assumption that relatively younger sedimentary units of Pleistocene-age or younger (<1.6 mya) would be more susceptible to surface water infiltration. Geology grouping of different map units is presented in Table A.4.1

Table A.4.1 Geologic grouping for different map units

Map Unit	Map Name	Anticipated Grain size of Weathered Material	Bedrock or Sedimentary	Impermeable/ Permeable	Geology Grouping
gr-m	Jennings; CA	Coarse	Bedrock	Impermeable	CB
grMz	Jennings; CA	Coarse	Bedrock	Impermeable	CB
Jcr	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Jhc	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Jsp	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Ka	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kbm	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kbp	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kcc	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kcg	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kcm	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kcp	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kd	San Diego & Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kdl	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kg	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgbf	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgd	San Diego & Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgdf	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgh	San Diego 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgm	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgm1	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgm2	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgm3	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgm4	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgp	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgr	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgu	San Diego 30' x 60'	Coarse	Bedrock	Impermeable	CB
Khg	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Ki	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kis	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kjd	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
KJem	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
KJld	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kjv	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB

Map Unit	Map Name	Anticipated Grain size of Weathered Material	Bedrock or Sedimentary	Impermeable/ Permeable	Geology Grouping
Klb	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Klh	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Klp	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Km	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kmg	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kmgp	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kmm	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kpa	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kpv	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kqbd	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kr	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Krm	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Krr	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kt	San Diego & Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Ktr	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kvc	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kwm	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kwp	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kwsr	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
m	Jennings; CA	Coarse	Bedrock	Impermeable	CB
Mzd	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Mzg	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Mzq	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Mzs	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
sch	Jennings; CA	Coarse	Bedrock	Impermeable	CB
Kp	San Diego & Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Ql	El Cajon 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
QTf	El Cajon 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Ec	Jennings; CA	Coarse	Sedimentary	Impermeable	CSI
K	Jennings; CA	Coarse	Sedimentary	Impermeable	CSI
Kccg	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Kcs	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Kl	San Diego, Oceanside & El Cajon 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Ku	Jennings; CA	Coarse	Sedimentary	Impermeable	CSI

Map Unit	Map Name	Anticipated Grain size of Weathered Material	Bedrock or Sedimentary	Impermeable/ Permeable	Geology Grouping
Qvof	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop8a	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop9a	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tmsc	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tmss	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tp	San Diego & El Cajon 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tpm	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tsc	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tscu	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tsd	San Diego & El Cajon 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tsdcg	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tsdss	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tsm	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tso	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tst	San Diego, Oceanside & El Cajon 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tt	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tta	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tmv	San Diego, Oceanside & El Cajon 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tsi	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvoa	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvoa11	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvoa12	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvoa13	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvoc	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop1	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop10	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop10a	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop11	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI

Map Unit	Map Name	Anticipated Grain size of Weathered Material	Bedrock or Sedimentary	Impermeable/ Permeable	Geology Grouping
Qvop11a	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop12	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop13	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop2	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop3	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop4	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop5	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop6	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop7	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop8	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop9	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tsa	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qof	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qof1	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qof2	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Q	Jennings; CA	Coarse	Sedimentary	Permeable	CSP
Qa	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qd	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qf	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qmb	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qop	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qw	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qyf	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qt	El Cajon 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qoa1-2	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qoa2-6	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qoa5	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qoa6	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qoa7	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP

Map Unit	Map Name	Anticipated Grain size of Weathered Material	Bedrock or Sedimentary	Impermeable/ Permeable	Geology Grouping
Qoc	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qop1	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qc	El Cajon 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qu	El Cajon 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qoa	San Diego, Oceanside & El Cajon 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qop2-4	San Diego 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qop3	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qop4	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qop6	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qop7	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qya	San Diego, Oceanside & El Cajon 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qyc	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Mzu	San Diego & Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
gb	Jennings; CA	Fine	Bedrock	Impermeable	FB
JTRm	El Cajon 30' x 60'	Fine	Bedrock	Impermeable	FB
Kat	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
Kc	El Cajon 30' x 60'	Fine	Bedrock	Impermeable	FB
Kgb	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
KJvs	El Cajon 30' x 60'	Fine	Bedrock	Impermeable	FB
Kmv	El Cajon 30' x 60'	Fine	Bedrock	Impermeable	FB
Ksp	El Cajon 30' x 60'	Fine	Bedrock	Impermeable	FB
Kvsp	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
Kwmt	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
Qv	Jennings; CA	Fine	Bedrock	Impermeable	FB
Tba	San Diego 30' x 60'	Fine	Bedrock	Impermeable	FB
Tda	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
Tv	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
Tvsr	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
Kgdfg	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
Ta	San Diego 30' x 60'	Fine	Sedimentary	Impermeable	FSI
Tcs	Oceanside 30' x 60'	Fine	Sedimentary	Impermeable	FSI
Td	San Diego & Oceanside	Fine	Sedimentary	Impermeable	FSI

Map Unit	Map Name	Anticipated Grain size of Weathered Material	Bedrock or Sedimentary	Impermeable/ Permeable	Geology Grouping
	30' x 60'				
Td+Tf	San Diego 30' x 60'	Fine	Sedimentary	Impermeable	FSI
Qls	San Diego, Oceanside & El Cajon 30' x 60'	Fine	Sedimentary	Impermeable	FSI
Tm	Oceanside 30' x 60'	Fine	Sedimentary	Impermeable	FSI
Tf	San Diego, Oceanside & El Cajon 30' x 60'	Fine	Sedimentary	Impermeable	FSI
Tfr	El Cajon 30' x 60'	Fine	Sedimentary	Impermeable	FSI
To	San Diego & El Cajon 30' x 60'	Fine	Sedimentary	Impermeable	FSI
Qpe	San Diego & Oceanside 30' x 60'	Fine	Sedimentary	Permeable	FSP
Mexico	San Diego 30' x 60'	NA	NA	Permeable	Other
Kuo	San Diego 30' x 60'	NA (Offshore)	NA	Permeable	Other
Teo	San Diego & Oceanside 30' x 60'	NA (Offshore)	Sedimentary	Permeable	Other
Tmo	Oceanside 30' x 60'	NA (Offshore)	Sedimentary	Permeable	Other
Qmo	San Diego 30' x 60'	NA (Offshore)	Sedimentary	Permeable	Other
QTso	San Diego 30' x 60'	NA (Offshore)	Sedimentary	Permeable	Other
af	San Diego & Oceanside 30' x 60'	Variable, dependent on source material	Sedimentary		Other

A.4.2 Quantitative Analysis

Soil loss estimates for each Geomorphic Landscape Unit were estimated using the Revised Universal Soil Loss Equation (RUSLE; Renard et al. 1997) listed below:

$$A = R \times K \times LS \times C \times P$$

Where

A = estimated average soil loss in tons/acre/year

R = rainfall-runoff erosivity factor

K = soil erodibility factor

LS = slope length and steepness factor

C = cover-management factor

P = support practice factor; assumed 1 for this analysis

Regional datasets used to estimate the inputs required to estimate the soil loss from each GLU are listed in table below:

Dataset	Source	Download year	Description
RUSLE – R Factor	SWRCB	2014	Regional R factor map was downloaded from ftp://swrcb2a.waterboards.ca.gov/pub/swrcb/dwq/cgp/Risk/RUSLE/RUSLE_R_Factor/
RUSLE – K Factor	SWRCB	2014	Regional K factor map was downloaded from ftp://swrcb2a.waterboards.ca.gov/pub/swrcb/dwq/cgp/Risk/RUSLE/RUSLE_K_Factor/
RUSLE – LS Factor	SWRCB	2014	Regional LS factor map was downloaded from ftp://swrcb2a.waterboards.ca.gov/pub/swrcb/dwq/cgp/Risk/RUSLE/RUSLE_LS_Factor/
RUSLE – C Factor	USEPA	2014	Regional C factor map was downloaded from http://www.epa.gov/esd/land-sci/emap_west_browser/pages/wemap_mm_sl_rusle_c_qt.htm#mapnav

GIS analysis was used to calculate the area weighted estimate of R, K, LS and C factors using the regional datasets listed in the table above. For the developed land cover the C factor was then adjusted to 0 from the regional estimate to account for management actions implemented on developed sites (e.g. impervious surfaces). Soil loss estimates ranged from 0 to 15.2 tons/acre/year.

For evaluating the degree of relative risk to a stream solely arising from changes in sediment and/or water delivery SCCWRP Technical Report 605, 2010 states:

> *"The challenge in implementing this step is that presently we have insufficient basis to defensibly identify either low-risk or high-risk conditions using these metrics. For example, channels that are close to a threshold for geomorphic change may display significant morphological changes under nothing more than natural year-to-year variability in flow or sediment load.*

- *Acknowledging this caveat, we nonetheless anticipate that changes of less than 10% in either driver are unlikely to instigate, on their own, significant channel changes. This value is a conservative estimate of the year-to-year variability in either discharge or sediment flux that can be accommodated by a channel system in a state of dynamic equilibrium. It does not "guarantee," however, that channel change may not occur—either in response to yet modest alterations in water or sediment delivery, or because of other urbanization impacts (e.g., point discharge of runoff or the trapping of the upstream sediment flux; see Booth 1990) that are not represented with this analysis.*
- *In contrast, recognizing a condition of undisputed "high risk" must await broader collection of regionally relevant data. We note that >60% reductions in predicted sediment production have resulted in both minimal (McGonigle) and dramatic (Agua Hedionda) channel changes, indicating that "more data" may never provide absolute guidance. At present, we suggest using predicted watershed changes of 50% or more in either runoff (as indexed by change in impervious area) or sediment production as provisional criteria for requiring a more detailed evaluation of both the drivers and the resisting factors for channel change, regardless of other screening-level assessments. Clearly, however, only more experience with the application of such "thresholds," and the actual channel conditions that accompany them, will provide a defensible basis for setting numeric standards."*

The following criterion was developed using the suggestions listed above and then used to assign relative sediment production rating to each GLU:

- Low: Soil Loss < 5.6 tons/acre/year [GLUs that have a soil loss of 0 to 5.6 tons/acre/year produces around 10% of the total coarse sediment soil loss from the study area]
- Medium: 5.6 tons/acre/year < Soil Loss < 8.4 tons/acre/year
- High: > 8.4 tons/acre/year [GLUs that have a soil loss greater than 8.4 tons/acre/year produces around 42% of the total coarse sediment soil loss from the study area]

Results from the quantitative analysis are summarized in Table A.4.2.

Table A.4.2 Relative Sediment Production for different Geomorphic Landscape Units

Geomorphic Landscape Unit (GLU)	Area (acres)	K	LS	C	R	A	Relative Sediment Production	Critical Coarse Sediment
CB-Agricultural/Grass-1	52883	0.20	4.67	0.14	50	6.5	Medium	No
CB-Agricultural/Grass-2	40633	0.21	5.19	0.14	56	8.3	Medium	No
CB-Agricultural/Grass-3	32617	0.22	6.04	0.14	57	10.6	High	Yes
CB-Agricultural/Grass-4	11066	0.23	7.38	0.14	57	13.5	High	Yes
CB-Developed-1	39746	0.22	3.77	0	49	0	Low	No
CB-Developed-2	32614	0.22	4.28	0	50	0	Low	No
CB-Developed-3	15841	0.22	4.86	0	49	0	Low	No
CB-Developed-4	1805	0.22	5.63	0	48	0	Low	No
CB-Forest-1	32231	0.20	6.38	0.14	39	6.8	Medium	No
CB-Forest-2	38507	0.20	7.20	0.13	45	8.8	High	Yes
CB-Forest-3	55303	0.20	8.14	0.13	48	10.6	High	Yes
CB-Forest-4	38217	0.20	9.95	0.14	50	13.6	High	Yes
CB-Other-1	1036	0.20	5.52	0.13	45	6.5	Medium	No
CB-Other-2	317	0.20	6.46	0.13	45	7.9	Medium	No
CB-Other-3	296	0.20	6.96	0.14	43	8.3	Medium	No
CB-Other-4	111	0.21	6.84	0.14	41	8.2	Medium	No
CB-Scrub/Shrub-1	88135	0.20	5.66	0.14	33	5.3	Low	No
CB-Scrub/Shrub-2	143694	0.20	6.51	0.14	37	6.8	Medium	No
CB-Scrub/Shrub-3	246703	0.21	7.33	0.14	41	8.4	Medium	No
CB-Scrub/Shrub-4	191150	0.21	8.28	0.14	42	9.8	High	No
CB-Unknown-1	1727	0.21	5.32	0.13	44	6.3	Medium	No
CB-Unknown-2	1935	0.21	5.95	0.13	44	7.1	Medium	No

Geomorphic Landscape Unit (GLU)	Area (acres)	K	LS	C	R	A	Relative Sediment Production	Critical Coarse Sediment
CB-Unknown-3	1539	0.22	6.21	0.13	44	7.7	Medium	No
CB-Unknown-4	278	0.22	6.61	0.13	44	8.4	High	Yes
CSI-Agricultural/Grass-1	14609	0.34	2.72	0.14	39	4.8	Low	No
CSI-Agricultural/Grass-2	9059	0.37	3.61	0.14	47	8.7	High	Yes
CSI-Agricultural/Grass-3	10096	0.38	3.99	0.14	47	9.8	High	Yes
CSI-Agricultural/Grass-4	2498	0.37	4.33	0.14	47	10.5	High	Yes
CSI-Developed-1	82371	0.28	2.51	0	39	0	Low	No
CSI-Developed-2	22570	0.30	2.66	0	41	0	Low	No
CSI-Developed-3	13675	0.30	2.89	0	40	0	Low	No
CSI-Developed-4	3064	0.27	3.20	0	39	0	Low	No
CSI-Forest-1	449	0.27	4.26	0.13	43	6.6	Medium	No
CSI-Forest-2	611	0.25	5.11	0.13	44	7.5	Medium	No
CSI-Forest-3	716	0.29	4.43	0.13	44	7.4	Medium	No
CSI-Forest-4	348	0.30	4.49	0.13	43	7.6	Medium	No
CSI-Other-1	319	0.31	2.50	0.13	32	3.2	Low	No
CSI-Other-2	83	0.27	3.01	0.13	39	4.3	Low	No
CSI-Other-3	45	0.28	3.03	0.13	39	4.5	Low	No
CSI-Other-4	13	0.24	4.01	0.14	39	5.2	Low	No
CSI-Scrub/Shrub-1	9051	0.26	3.53	0.13	39	4.7	Low	No
CSI-Scrub/Shrub-2	10802	0.27	4.36	0.13	41	6.3	Medium	No
CSI-Scrub/Shrub-3	28220	0.26	4.82	0.13	41	6.7	Medium	No
CSI-Scrub/Shrub-4	20510	0.26	5.52	0.13	41	7.8	Medium	No
CSI-Unknown-1	5292	0.28	2.38	0.13	36	3.1	Low	No

Geomorphic Landscape Unit (GLU)	Area (acres)	K	LS	C	R	A	Relative Sediment Production	Critical Coarse Sediment
CSI-Unknown-2	2074	0.29	2.98	0.13	40	4.5	Low	No
CSI-Unknown-3	2171	0.27	3.04	0.13	39	4.2	Low	No
CSI-Unknown-4	676	0.26	3.04	0.13	38	3.8	Low	No
CSP-Agricultural/Grass-1	59327	0.22	3.01	0.14	44	4.0	Low	No
CSP-Agricultural/Grass-2	8426	0.23	3.81	0.14	42	5.2	Low	No
CSP-Agricultural/Grass-3	2377	0.24	4.05	0.14	41	5.6	Low	No
CSP-Agricultural/Grass-4	291	0.22	6.28	0.14	52	10.1	High	Yes
CSP-Developed-1	85283	0.27	2.10	0	42	0	Low	No
CSP-Developed-2	7513	0.26	2.77	0	42	0	Low	No
CSP-Developed-3	2317	0.27	2.70	0	40	0	Low	No
CSP-Developed-4	272	0.27	2.76	0	38	0	Low	No
CSP-Forest-1	14738	0.22	4.52	0.14	44	6.0	Medium	No
CSP-Forest-2	3737	0.22	5.99	0.14	45	8.2	Medium	No
CSP-Forest-3	1858	0.21	6.42	0.14	45	8.5	High	Yes
CSP-Forest-4	484	0.21	7.62	0.14	48	10.2	High	Yes
CSP-Other-1	7404	0.23	2.61	0.14	39	3.2	Low	No
CSP-Other-2	343	0.24	3.68	0.13	40	4.8	Low	No
CSP-Other-3	126	0.24	3.76	0.13	40	4.9	Low	No
CSP-Other-4	17	0.24	4.19	0.13	39	5.3	Low	No
CSP-Scrub/Shrub-1	22583	0.23	3.75	0.14	41	4.8	Low	No
CSP-Scrub/Shrub-2	8938	0.24	5.63	0.14	40	7.1	Medium	No
CSP-Scrub/Shrub-3	7186	0.23	6.15	0.13	39	7.5	Medium	No
CSP-Scrub/Shrub-4	2609	0.22	7.16	0.14	43	9.3	High	Yes

Geomorphic Landscape Unit (GLU)	Area (acres)	K	LS	C	R	A	Relative Sediment Production	Critical Coarse Sediment
CSP-Unknown-1	6186	0.25	2.63	0.13	40	3.4	Low	No
CSP-Unknown-2	744	0.27	3.49	0.13	39	4.8	Low	No
CSP-Unknown-3	350	0.28	3.32	0.13	38	4.5	Low	No
CSP-Unknown-4	78	0.28	3.26	0.13	40	4.5	Low	No
FB-Agricultural/Grass-1	6103	0.25	5.49	0.14	49	9.2	High	No
FB-Agricultural/Grass-2	7205	0.25	5.87	0.14	51	10.1	High	No
FB-Agricultural/Grass-3	6730	0.24	6.43	0.14	53	11.3	High	No
FB-Agricultural/Grass-4	2586	0.22	8.62	0.14	57	15.2	High	No
FB-Developed-1	10116	0.28	3.94	0	46	0	Low	No
FB-Developed-2	9075	0.28	4.41	0	45	0	Low	No
FB-Developed-3	5499	0.27	4.72	0	44	0	Low	No
FB-Developed-4	785	0.27	5.08	0	43	0	Low	No
FB-Forest-1	3780	0.21	7.24	0.13	39	8.0	Medium	No
FB-Forest-2	7059	0.21	7.53	0.13	43	8.8	High	No
FB-Forest-3	13753	0.22	8.02	0.13	43	9.7	High	No
FB-Forest-4	8899	0.26	9.63	0.13	35	11.5	High	No
FB-Other-1	172	0.26	5.72	0.13	44	8.6	High	No
FB-Other-2	75	0.26	5.97	0.13	38	7.7	Medium	No
FB-Other-3	76	0.28	6.27	0.13	34	7.6	Medium	No
FB-Other-4	36	0.31	6.70	0.13	33	8.6	High	No
FB-Scrub/Shrub-1	10297	0.24	6.94	0.14	36	8.3	Medium	No
FB-Scrub/Shrub-2	25150	0.25	7.24	0.14	38	9.0	High	No
FB-Scrub/Shrub-3	70895	0.25	7.89	0.13	38	10.0	High	No

Geomorphic Landscape Unit (GLU)	Area (acres)	K	LS	C	R	A	Relative Sediment Production	Critical Coarse Sediment
FB-Scrub/Shrub-4	70679	0.26	9.05	0.14	39	12.1	High	No
FB-Unknown-1	654	0.30	5.33	0.13	37	7.6	Medium	No
FB-Unknown-2	829	0.29	5.26	0.13	40	7.9	Medium	No
FB-Unknown-3	1062	0.29	5.54	0.13	39	8.2	Medium	No
FB-Unknown-4	299	0.28	6.02	0.13	38	8.4	High	No
FSI-Agricultural/Grass-1	8462	0.32	3.91	0.13	24	3.9	Low	No
FSI-Agricultural/Grass-2	4979	0.33	4.29	0.13	31	5.7	Medium	No
FSI-Agricultural/Grass-3	4808	0.34	4.26	0.13	34	6.3	Medium	No
FSI-Agricultural/Grass-4	1055	0.35	4.11	0.13	36	6.7	Medium	No
FSI-Developed-1	9953	0.29	3.09	0	34	0	Low	No
FSI-Developed-2	4972	0.31	3.22	0	37	0	Low	No
FSI-Developed-3	3350	0.29	3.30	0	36	0	Low	No
FSI-Developed-4	763	0.28	3.31	0	37	0	Low	No
FSI-Forest-1	186	0.33	4.62	0.13	37	7.2	Medium	No
FSI-Forest-2	217	0.35	4.47	0.13	39	7.9	Medium	No
FSI-Forest-3	262	0.37	4.71	0.13	40	9.2	High	No
FSI-Forest-4	111	0.36	4.73	0.13	40	9.2	High	No
FSI-Other-1	266	0.31	3.11	0.13	24	2.9	Low	No
FSI-Other-2	81	0.30	3.29	0.13	25	3.1	Low	No
FSI-Other-3	56	0.31	3.04	0.13	27	3.2	Low	No
FSI-Other-4	15	0.29	3.57	0.13	33	4.4	Low	No
FSI-Scrub/Shrub-1	2241	0.27	4.46	0.13	29	4.5	Low	No
FSI-Scrub/Shrub-2	3911	0.28	4.96	0.13	31	5.7	Medium	No

Geomorphic Landscape Unit (GLU)	Area (acres)	K	LS	C	R	A	Relative Sediment Production	Critical Coarse Sediment
FSI-Scrub/Shrub-3	7590	0.29	5.05	0.13	34	6.3	Medium	No
FSI-Scrub/Shrub-4	3502	0.30	5.14	0.13	37	7.5	Medium	No
FSI-Unknown-1	1117	0.29	2.83	0.13	27	3.0	Low	No
FSI-Unknown-2	780	0.30	3.44	0.13	32	4.3	Low	No
FSI-Unknown-3	855	0.29	3.41	0.13	31	4.0	Low	No
FSI-Unknown-4	285	0.28	3.21	0.13	32	3.7	Low	No
FSP-Agricultural/Grass-1	13	0.22	2.22	0.13	40	2.5	Low	No
FSP-Agricultural/Grass-2	3	0.22	2.59	0.13	40	3.0	Low	No
FSP-Agricultural/Grass-3	2	0.22	2.69	0.13	40	3.2	Low	No
FSP-Agricultural/Grass-4	0	0.20	2.94	0.12	40	2.9	Low	No
FSP-Developed-1	180	0.26	2.85	0	40	0	Low	No
FSP-Developed-2	13	0.25	2.69	0	40	0	Low	No
FSP-Developed-3	8	0.21	2.25	0	40	0	Low	No
FSP-Developed-4	0	0.21	2.29	0	40	0	Low	No
FSP-Forest-1	8	0.22	2.29	0.14	40	2.9	Low	No
FSP-Forest-2	5	0.20	2.22	0.14	40	2.5	Low	No
FSP-Forest-3	0	0.20	2.22	0.14	40	2.5	Low	No
FSP-Other-1	1307	0.20	2.38	0.14	40	2.7	Low	No
FSP-Other-2	34	0.21	2.36	0.14	40	2.7	Low	No
FSP-Other-3	8	0.22	2.56	0.13	40	3.0	Low	No
FSP-Other-4	0	0.43	4.35	0.12	40	9.3	High	No
FSP-Scrub/Shrub-1	147	0.23	2.68	0.14	40	3.3	Low	No
FSP-Scrub/Shrub-2	18	0.23	2.55	0.14	40	3.3	Low	No

Geomorphic Landscape Unit (GLU)	Area (acres)	K	LS	C	R	A	Relative Sediment Production	Critical Coarse Sediment
FSP-Scrub/Shrub-3	4	0.20	2.23	0.14	40	2.6	Low	No
FSP-Scrub/Shrub-4	0	0.20	1.70	0.12	40	1.7	Low	No
FSP-Unknown-1	40	0.20	1.87	0.13	40	1.9	Low	No
FSP-Unknown-2	5	0.20	1.99	0.12	40	2.0	Low	No
FSP-Unknown-3	1	0.20	2.39	0.12	40	2.4	Low	No
O-Agricultural/Grass-1	2433	0.20	2.93	0.14	34	2.8	Low	No
O-Agricultural/Grass-2	112	0.21	3.44	0.14	32	3.2	Low	No
O-Agricultural/Grass-3	30	0.23	3.89	0.13	32	3.8	Low	No
O-Agricultural/Grass-4	1	0.26	6.47	0.13	37	7.9	Medium	No
O-Developed-1	8327	0.27	1.37	0	39	0	Low	No
O-Developed-2	474	0.25	2.12	0	40	0	Low	No
O-Developed-3	157	0.26	3.07	0	41	0	Low	No
O-Developed-4	26	0.24	3.89	0	41	0	Low	No
O-Forest-1	235	0.22	6.15	0.13	43	7.6	Medium	No
O-Forest-2	67	0.21	5.07	0.13	45	6.6	Medium	No
O-Forest-3	45	0.21	5.43	0.13	47	7.3	Medium	No
O-Forest-4	20	0.20	5.95	0.13	59	9.0	High	No
O-Other-1	9362	0.25	3.86	0.13	36	4.3	Low	No
O-Other-2	344	0.24	3.32	0.13	35	3.5	Low	No
O-Other-3	120	0.23	4.86	0.13	35	5.0	Low	No
O-Other-4	37	0.22	5.64	0.13	39	6.6	Medium	No
O-Scrub/Shrub-1	688	0.22	4.83	0.13	40	5.7	Medium	No
O-Scrub/Shrub-2	224	0.22	5.80	0.13	36	6.3	Medium	No

Geomorphic Landscape Unit (GLU)	Area (acres)	K	LS	C	R	A	Relative Sediment Production	Critical Coarse Sediment
O-Scrub/Shrub-3	209	0.22	6.47	0.13	41	7.5	Medium	No
O-Scrub/Shrub-4	96	0.22	6.62	0.13	44	8.2	Medium	No
O-Unknown-1	1236	0.28	1.60	0.12	26	1.5	Low	No
O-Unknown-2	62	0.27	1.48	0.13	36	1.8	Low	No
O-Unknown-3	15	0.29	3.52	0.13	38	4.9	Low	No
O-Unknown-4	7	0.34	3.87	0.12	40	6.6	Medium	No

GLU Nomenclature: Geology – Land Cover – Slope Category

Geology Categories:

CB Coarse Bedrock

CSI Coarse Sedimentary Impermeable

CSP Coarse Sedimentary Permeable

FB Fine Bedrock

FSI Fine Sedimentary Impermeable

FSP Fine Sedimentary Permeable

O Other

Slope Categories:

1 0%-10%

2 10% - 20%

3 20% - 40%

4 > 40%

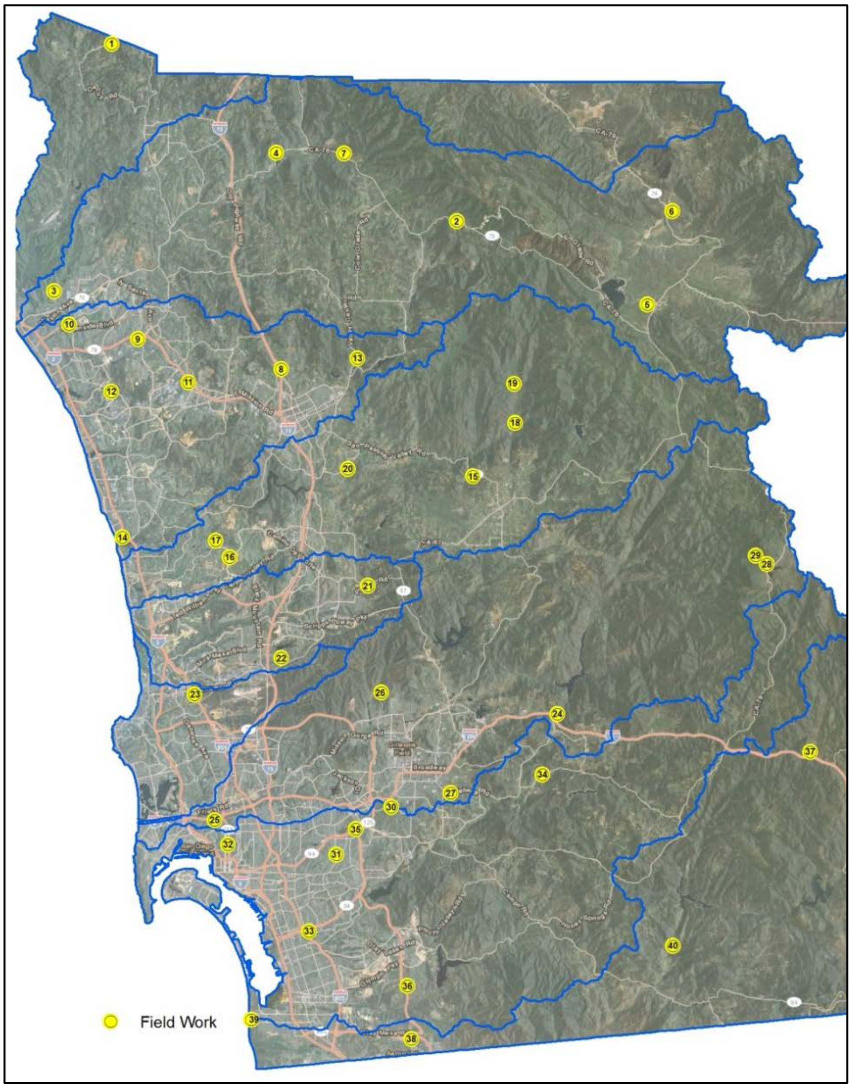
A4.3 Field Assessment

Site Selection:

Forty locations were selected from the study region for field assessment. Sites were selected such that they are accessible by existing road network based on review of satellite imagery and are uniformly distributed considering the following criteria:

- Geologic grouping
- Land cover
- Slope category
- WMA
- Jurisdiction

Yellow circles in the figure below shows the 40 locations for which field assessment was performed.



Pre-Field Activities

Prior to conducting field activities, the consultant team reviewed available published geologic information at each site location and prepared satellite imagery of each site using Google Earth™. Pre-field activities consisted of evaluating site access at each location using aerial imagery and logistics were coordinated based on regional site location to maximize field efficiency.

Site Reconnaissance

Site reconnaissance was performed at forty locations between 22 January and 7 February 2014 by a team of geologists. The reconnaissance consisted of:

- Visual soil classification,
- Assessing existing vegetative cover (0-100%),
- Qualitative assignment of existing sediment production (low, medium, and high) [based on existing vegetative cover],
- Qualitative assignment of potential sediment production (low, medium, and high)[assuming there is 0% vegetative cover], and
- Identifying existing erosional features.

Descriptions and visual classifications of the surficial materials were based on the Unified Soil Classification System (USCS). Underlying geologic units were confirmed where exposed formations were observed within the individual site limits.

SITE AND GEOLOGIC CONDTIONS

Our knowledge of the site conditions has been developed from a review of available geologic literature, previous geologic and geotechnical investigations by the consultant team in the study region, professional experience, site reconnaissance, and field investigations performed for this study.

Surface Conditions

Site locations were sited in open space with the exception of sites ID-27, -30, and -31 which were situated within developed areas with paved streets and sidewalks. The surface conditions at the site locations were characterized by sloping terrain varying from relatively flat (< 5%) to very steep slopes (> 40%). At the time of our reconnaissance the natural hillsides along the areas of interest were covered by varying degrees of moderate to dense growth scrub brush, low grasses, and scattered trees.

Existing erosional and geomorphic features at each site location were identified where possible. The observed erosional features included notable drainages, rilling, scour, and sediment accumulation. Observed geomorphic features included areas of minor slope instability and surficial slumping. Several sources of ground disturbance were identified during the site reconnaissance included active grading operations and bioturbation.

An evaluation of the existing and potential sediment production for each site was determined based on surface conditions. Sediment production was assigned as "high, medium, or low" based on the existing conditions and consultant team's professional experience.

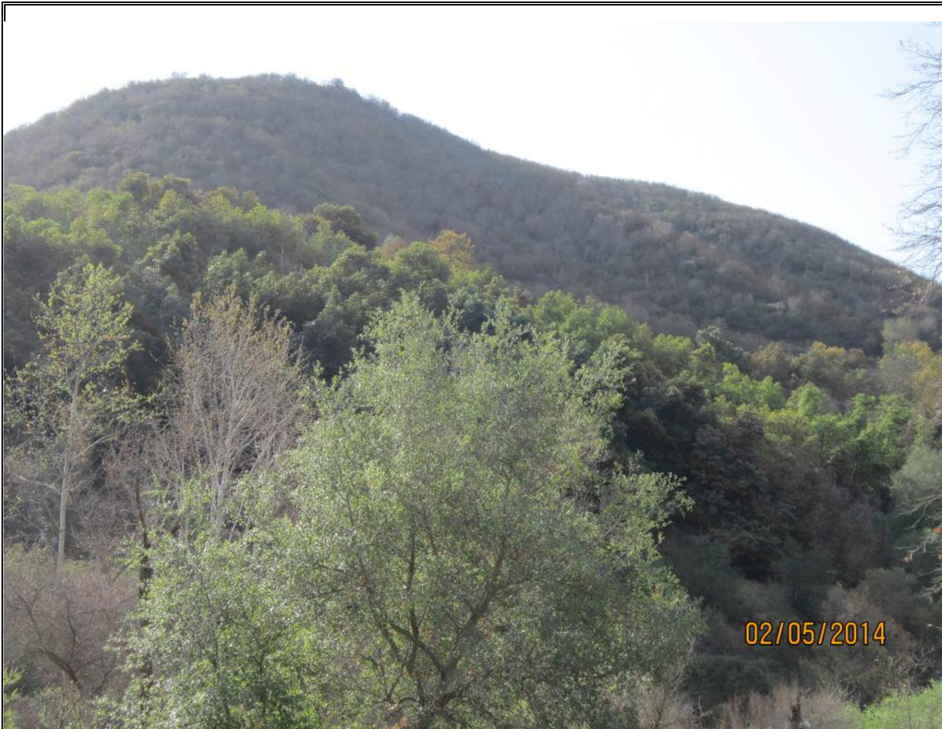
Surficial Deposits

Surficial deposits, including topsoil, alluvium, colluvium, slopewash, and residual soils are present in portions of the study area within the natural drainages and mantling the slope areas. The composition and grain size of these materials are variable depending on the age, parent sources, and mode of deposition.

Geologic Conditions

Our knowledge of the subsurface conditions at the site locations is based on a review of available published geologic information, professional experience, site reconnaissance, previous explorations and geotechnical investigations performed by the consultant team in the study region.

Field Assessment Photo Log



Field Visit ID-1

GLU: CB-Scrub/Shrub-4

View: Looking southwest

Existing sediment production: Med

Potential sediment production: High

Existing veg. cover: 90%

Field Visit ID-2

GLU: CB-Forest-4

View: Looking north

Existing sediment production: Med

Potential sediment production: High

Existing veg. cover: 95%

Field Visit ID-3

GLU: CSI-Agricultural/ Grass-3

View: Looking southwest

Existing sediment production: Low to Med

Potential sediment production:

Med to High

Existing veg. cover:

95-100%

Field Visit ID-4

GLU: CSI-Scrub/Shrub-2

View: Looking north

Existing sediment production: Med

Potential sediment production: High

Existing veg. cover: 70%

	**Field Visit ID-5** **GLU: CSP-Agricultural/ Grass-1** View: Looking southwest Existing sediment production: Low to Med Potential sediment production: Med Existing veg. cover: 90%
	**Field Visit ID-6** **GLU: CSP-Agricultural/ Grass-3** View: Looking east Existing sediment production: Low to Med Potential sediment production: Low to Med Existing veg. cover: Southeast slope ~50% Northeast slope ~70%

Field Visit ID-7

GLU: CSP-Forest-3

View: Looking east

Existing sediment production: Med to High

Potential sediment production: High

Existing veg. cover: 75-80%

Field Visit ID-8

GLU: CB-Scrub/Shrub-3

View: Looking southeast

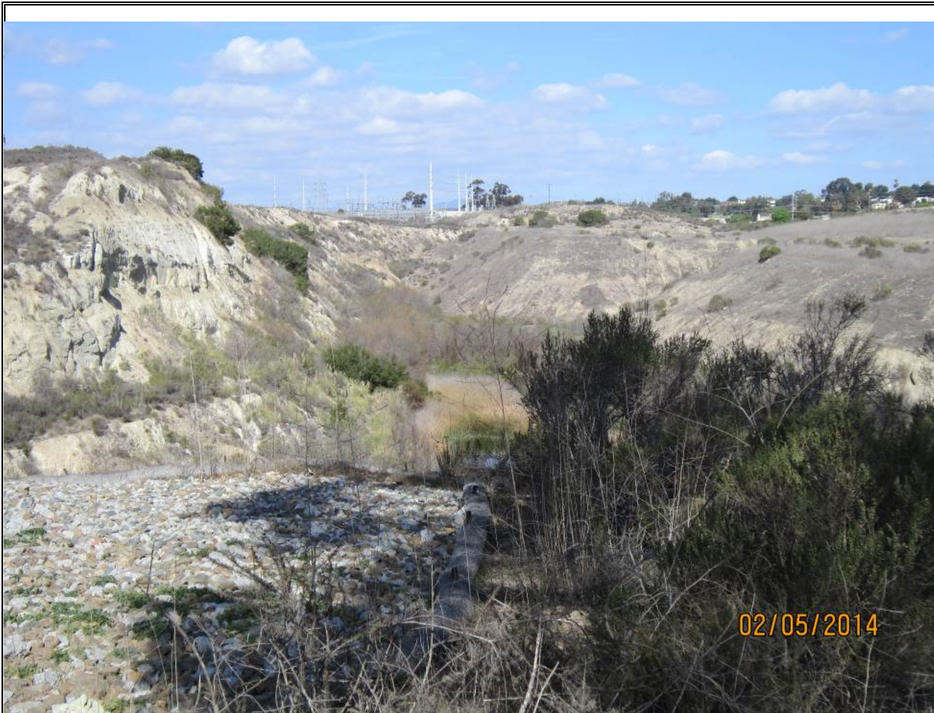
Existing sediment production: Low to Med

Potential sediment production:

Med to High

Existing veg. cover: 90-95%

	**Field Visit ID-9** **GLU: CB-Agricultural/ Grass-2** View: Looking northwest Existing sediment production: Low to Med Potential sediment production: Med Existing veg. cover: 70%

	**Field Visit ID-10** **GLU: CSI-Unknown-2** View: Looking north Existing sediment production: Med to High Potential sediment production: High Existing veg. cover: 75%

Field Visit ID-11

GLU: CSI-Agricultural/ Grass-2

View: Looking east

Existing sediment production: Low

Potential sediment production: Med

Existing veg. cover: 85%

Field Visit ID-12

GLU: CSP-Unknown-2

View: Looking southwest

Existing sediment production: Low

Potential sediment production:

Low to Med

Existing veg. cover: 50%

<table>
<tr><td>
</td><td>

Field Visit ID-13

GLU: CSP-Scrub/Shrub-2

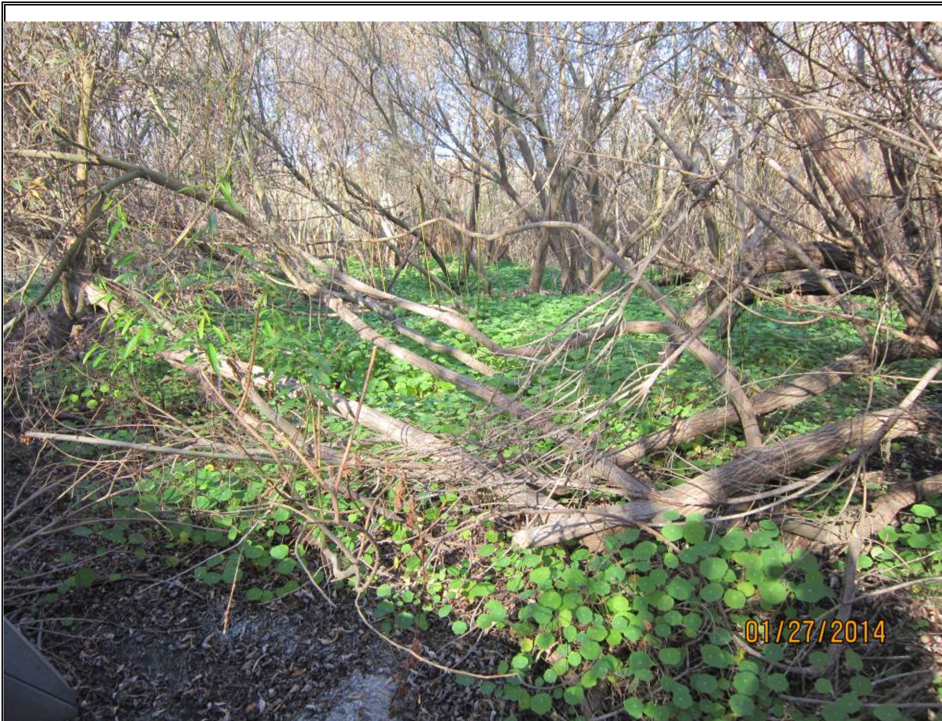
View: Looking southeast

Existing sediment production: Med

Potential sediment production:

Med to High

Existing veg. cover: 80-85%
</td></tr>
</table>

<table>
<tr><td>
</td><td>

Field Visit ID-14

GLU: FSP-Scrub/Shrub-1

View: Looking northeast

Existing sediment production: Low

Potential sediment production:

Low to Med

Existing veg. cover:

95-100%
</td></tr>
</table>

Field Visit ID-15

GLU: CB-Agricultural/ Grass-4

View: Looking west

Existing sediment production: Med

Potential sediment production: High

Existing veg. cover: 95%

.

Field Visit ID-16

GLU: CB-Agricultural/ Grass-3

View: Looking south

Existing sediment production: High*

Potential sediment production: High

Existing veg. cover: 90-95%

* Area was burned in 2014 fires after the field assessment so existing sediment production was adjusted to High (based on potential sediment production) from Medium

Field Visit ID-17

GLU: CSI-Scrub/Shrub-4

View: Looking west

Existing sediment production: Med

Potential sediment production: High

Existing veg. cover: 95%

Field Visit ID-18

GLU: CSP-Forest-1

View: Looking southwest

Existing sediment production: Low to Med

Potential sediment production: Med

Existing veg. cover: 80%

Field Visit ID-19

GLU: CSP-Scrub/Shrub-3

View: Looking southwest

Existing sediment production: Low to Med

Potential sediment production:

Med to High

Existing veg. cover: 60%

Field Visit ID-20

GLU: CSP-Unknown-1

View: Looking southeast

Existing sediment production: Low

Potential sediment production: Med

Existing veg. cover: 95%

Field Visit ID-21

GLU: CB-Unknown-3

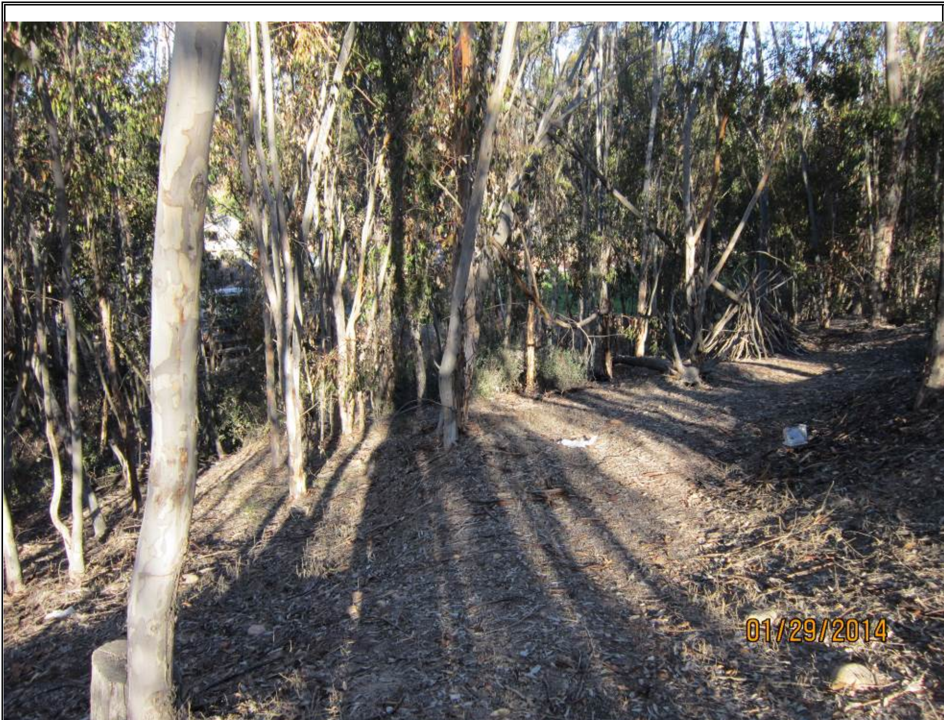
View: Looking northwest

Existing sediment production: Low to Med

Potential sediment production:

Med to High

Existing veg. cover: 50-60%



Field Visit ID-22

GLU: CSI-Forest-3

View: Looking east

Existing sediment production: Low

Potential sediment production: Med

Existing veg. cover: 60%

Field Visit ID-23

GLU: CSI-Scrub/Shrub-1

View: Looking north

Existing sediment production: Low

Potential sediment production: Low

Existing veg. cover: 80%

Field Visit ID-24

GLU: CB-Unknown-4

View: Looking northeast

Existing sediment production: Low to Med

Potential sediment production: High

Existing veg. cover: 80%

Field Visit ID-25

GLU: CSI-Agricultural/ Grass-4

View: Looking east

Existing sediment production: Low

Potential sediment production: Med-High

Existing veg. cover: 95%

Field Visit ID-26

GLU: CSI-Scrub/Shrub-3

View: Looking east

Existing sediment production: Low

Potential sediment production: Med

Existing veg. cover: 100%

.

	**Field Visit ID-27** **GLU: CSP-Developed-2** View: Looking north Existing sediment production: Low Potential sediment production: Low Existing veg. cover: 30-35% .

	**Field Visit ID-28** **GLU: CSP-Agricultural/ Grass-2** View: Looking north Existing sediment production: Low Potential sediment production: Med Existing veg. cover: 90-95% .

Field Visit ID-29

GLU: FB-Forest-3

View: Looking northwest

Existing sediment production: Med

Potential sediment production: High

Existing veg. cover: 80-85%

Field Visit ID-30

GLU: CB-Developed-4

View: Looking northeast

Existing sediment production: Low

Potential sediment production: Med

Existing veg. cover: 70%

.

Field Visit ID-31

GLU: CSI-Developed-3

View: Looking north

Existing sediment production: Low

Potential sediment production: Low

Existing veg. cover: 30-35%

Field Visit ID-32

GLU: CSI-Unknown-3

View: Looking west

Existing sediment production: Low to Med

Potential sediment production: Med

Existing veg. cover: 70-75%

Field Visit ID-33

GLU: CSP-Scrub/Shrub-1

View: Looking northeast

Existing sediment production: Low to Med

Potential sediment production:

Med to High

Existing veg. cover: 70%

Field Visit ID-34

GLU: CSP-Developed-2

View: Looking south

Existing sediment production: Low

Potential sediment production: Low

Existing veg. cover: 95%

Field Visit ID-35

GLU: FB-Scrub/Shrub-3

View: Looking northeast

Existing sediment production: Low

Potential sediment production: Med

Existing veg. cover: 90-95%

Field Visit ID-36

GLU: FSI-Agricultural/ Grass-2

View: Looking northeast

Existing sediment production: Low

Potential sediment production: Med

Existing veg. cover: 95%

<table>
<tr><td></td><td>Field Visit ID-37
GLU: CB-Forest-3

View: Looking southeast

Existing sediment production: Med-High

Potential sediment production: High

Existing veg. cover: 75-80%</td></tr>
</table>

<table>
<tr><td></td><td>Field Visit ID-38
GLU: CSI-Agricultural/ Grass-1

View: Looking northeast

Existing sediment production: Low

Potential sediment production: Med

Existing veg. cover: 85%</td></tr>
</table>

Field Visit ID-39

GLU: CSP-Developed-1

View: Looking west

Existing sediment production: Low

Potential sediment production: Low

Existing veg. cover: 30-35%

Field Visit ID-40

GLU: CSP-Scrub/Shrub-4

View: Looking south

Existing sediment production: Med

Potential sediment production: High

Existing veg. cover: 90-95%

Geologic Group

Carlsbad Watershed - HU 904.00, 211 mi2

Exhibit Date: Sept. 8, 2014

Geosyntec consultants

RICK ENGINEERING COMPANY

Potential Critical Coarse Sediment Yield Areas

Carlsbad Watershed - HU 904.00, 211 mi2

Exhibit Date: Sept. 8, 2014

Geosyntec consultants

RICK ENGINEERING COMPANY

ATTACHMENT A.5

PHYSICAL STRUCTURES

A.5 Physical Structures

The desktop-level analysis to identify existing physical structures within the nine watershed management areas within the San Diego region utilized the following GIS data sources:

- ESRI ArcMap, Google Earth, and Google Maps products
- Federal Emergency Management Agency (FEMA) Flood Insurance Study (FIS) Flood Profiles and FEMA Flood Insurance Rate Map (FIRM)
- National Flood Hazard Layer (NFHL)
- Municipal master drainage plans (as provided)
- San Diego Geographic Information Source (SanGIS) Municipal Boundaries and Hydrologic Basins
- United States Geological Survey (USGS) National Hydrography Dataset (NHD) California data
- Stream data generated as indicated in Section 2.2

The following documents the process used to identify the physical structures along the reaches and the resulting GIS data:

- The process began by importing the data sources indicated above into a single ArcMap document that served as a master map file from which all further analysis proceeded.
- The data were screened and selected for inclusion as appropriate to the project scope.
- Point features were placed along river reach line segments to coincide with visually identified structures, utilizing different feature symbols according to the type of infrastructure.
- In the case of levees, the point was placed at the downstream-most end of the FEMA NFHL Shapefile. All point features generated in this task appear in the GIS shapefile.
- Municipal boundaries intersecting river reaches were identified to identify the applicable municipal drainage plan data.
- Point feature attributes and associated information for Physical Structures GIS shapefile is indicated in Table A.5.1 below.

Table A.5.1: Structure Identification Point Feature Attribute Development and Information

Attribute	Description
Struct_ID	The Structure ID field provides a six-digit identification number based upon the structure's specific location within a watershed. The first three digits in the code reflect the structure's Hydrologic Unit (HU) Basin number (ranging between 902-911 for Region 9, as defined in the Water Quality Control Plan for the San Diego Basin). The subsequent three digits reflect the structure's location along the reach, ascending along the channel from the headwaters to tailwaters (ranging between 001-999, beginning at the confluence and increasing in the upstream direction).

Attribute	Description
WMA	The Watershed Management Area field provides the name of the watershed in which the structure exists. The WMA corresponds with the HU identified in the first three digits in the Struct_ID (e.g., 911, Tijuana Watershed).
Channel_ID	The Channel ID field provides the name of the channel in which the structure exists.
Struct_Typ	The Structure Type field classifies known structures as one of the following types:, Bridge, Culvert, Dam, Energy Dissipater, Flood Management Basin, Flood Wall, Grade Control, Levee, Pipeline, Weir.
Struct_Dtl	The Structure Detail field provides known quantitative information for multi-section culverts.
Struct_Mtl	The Structure Material field provides known qualitative information for structure material composition.
Struct_Shp	The Structure Shape field provides known geometric information for culvert shapes, and is classified as one of the following types: Arch, Box, Pipe.
Jurisd_ID	The Jurisdiction ID field, when applicable, provides the known separate structure identification number developed and utilized by the jurisdiction or entity responsible for creating and distributing the coinciding structure Shapefile data used for this analysis. This number was copied from the coinciding external Shapefile data attribute field best representing a unique jurisdiction or entity-based identification number (external Shapefile data received from regional WMAA data call; for jurisdictional information, see "Other" attribute field). Coinciding external Shapefile data was used to determine various structure attributes.
Plan_ID	The Plan ID field, when applicable, provides the known structure plan number corresponding with the Jurisdiction ID. This number was copied from the coinciding external Shapefile data attribute field best representing a unique plan number received from the regional WMAA data call (external Shapefile data received from regional WMAA data call; for jurisdictional information, see "Other" field). Coinciding external Shapefile data was used to determine various structure attributes.
Diameter	The Diameter field, when applicable, provides the known diameter (in US feet) for culverts.
Length	The Length field, when applicable, provides the known length (in US feet) for select structure types. When lengths were determined using FEMA FIS Flood Profiles, the scaled horizontal distances along the indicated roadway or channel slope were used.
Width	The Width field, when applicable, provides the known width (in US feet) for select structure types.
Height	The Height field, when applicable, provides the known height (in US feet) for select structure types. When heights were determined using FEMA FIS Flood Profiles, the scaled vertical distances from channel bed to indicated roadway bottom were used.
US_Invert	The Upstream Invert field, when applicable, provides the known upstream invert elevation (in US feet) for select structure types.
DS_Invert	The Downstream Invert field, when applicable, provides the known downstream invert elevation (in US feet) for select structure types.

Attribute	Description
RD_EL_NAVD	The Roadway Elevation (NAVD) field, when applicable, provides the known roadway elevation (in US feet, NAVD) for select structure types. When roadway elevations were determined using FEMA FIS Flood Profiles, the horizontal projection onto the vertical grid scales were used.
Loc_Descr	The Location Description field, when applicable, provides information for structures crossing a known roadway. In nearly all cases, Google Earth imagery was used to determine the roadway name.
Other	The Other field is used to convey any information not present within the preceding fields. Typically, "other" information includes jurisdictional, plan, and supplemental dimensions for a given structure.

Example Structure Identification

The following example demonstrates the structure identification process for a discrete structure (ID 907029) along the San Diego River. The San Diego River is located in the San Diego River watershed (WMA 907). Scanning the river from lower to higher reached, a new point feature was placed at the road crossing over the San Diego River as indicated in Figure A.5.1. Select attributes of this particular structure were available from the FEMA NFHL as displayed in the highlighted boxes in Figure A.5.1. Additional attributes such as the culvert height, length, roadway elevation, and name were also determined from the FIS Flood Profile as indicated in Figure A.5.2. Satellite imagery (e.g., Google) was used to verify the existence of structure. In this case, the most current Google Map data indicated that the culvert still exists and that the roadway name has been changed to Qualcomm Way. When structures could not be verified with satellite imagery, the structure identification was based solely upon the information provided or readily available and was not physically verified in the field. Figure A.5.3 displays an example of imagery used to identify structures.

Figure A.5.1: Typical ArcMap Window

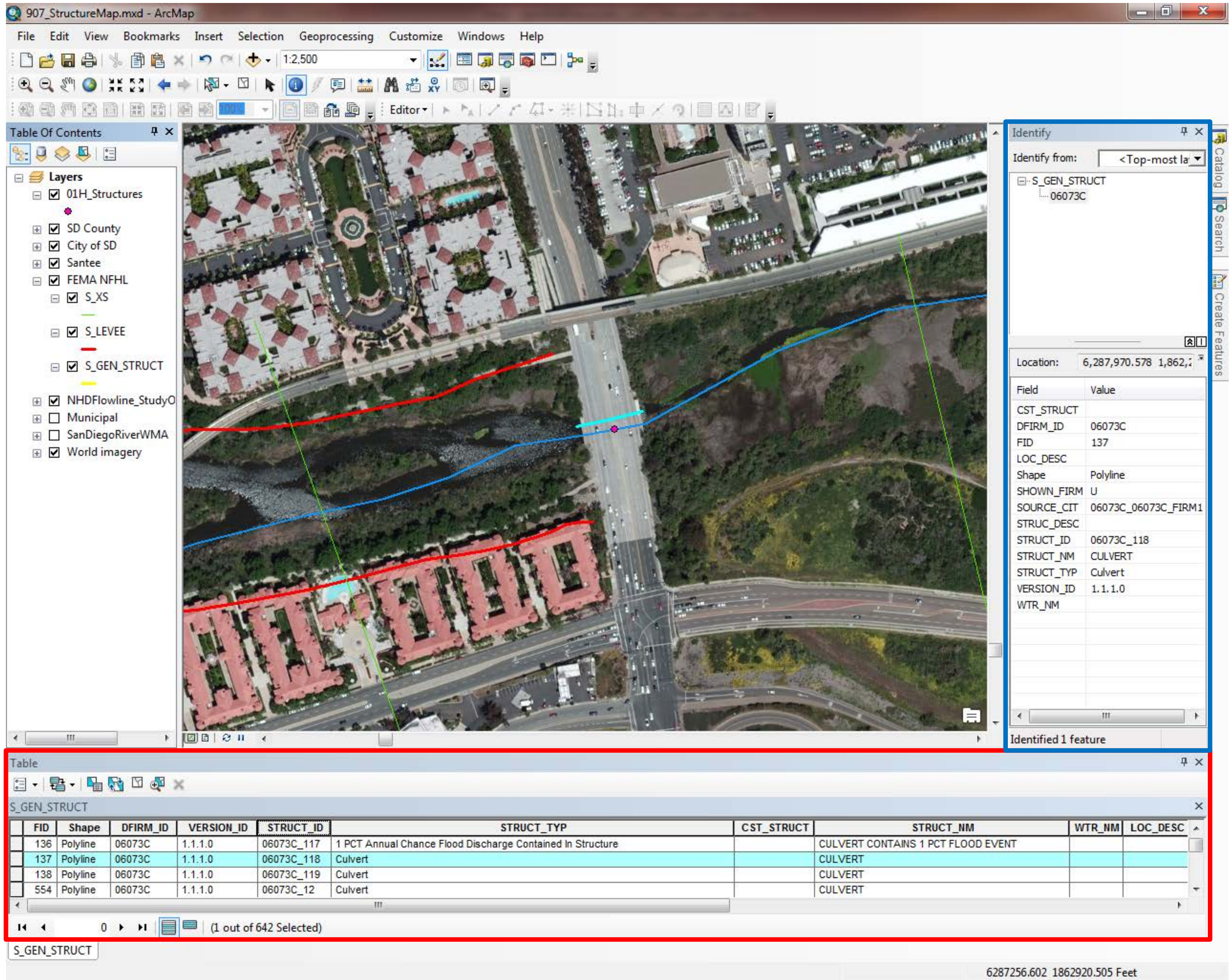
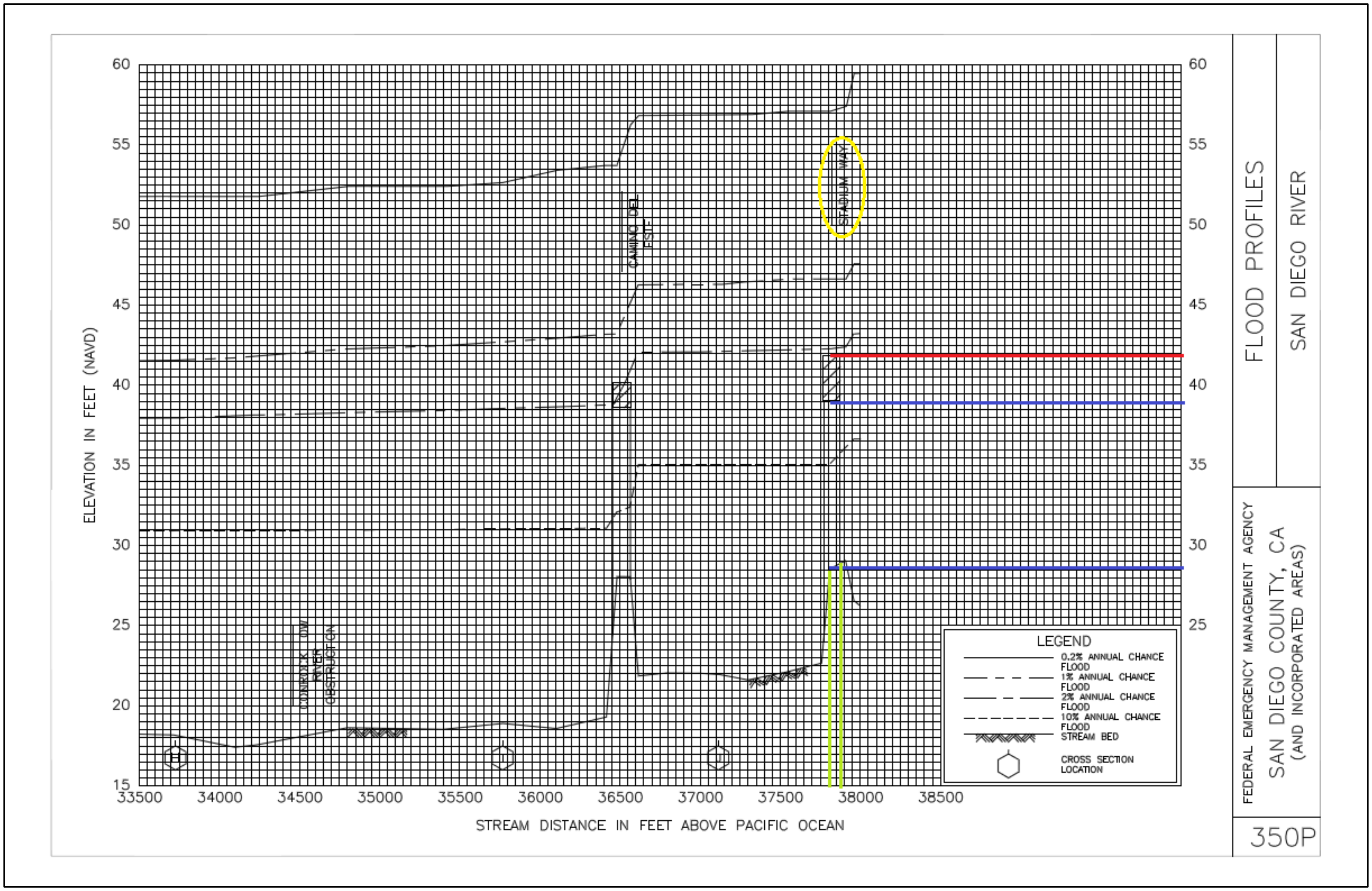


Figure A.5.2: Typical FEMA FIS Flood Profile



Legend: roadway elevation (red), roadway name (yellow), culvert height (blue), culvert width (green)

Figure A.5.3: Google Map Imagery for Structure Identification

The following bridge structure dimensional attributes were included in the point feature attributes:

- length 110 feet
- height 10 feet
- roadway elevation 41.9 feet

The attribute table associated with the identified structure included in the GIS shapefile is indicated in Table A.5.2.

Table A.5.2: Structure 907029 Attribute Table

Attribute	Description
Struct_ID	907029
WMA	San Diego
Channel_ID	San Diego River
Struct_Typ	Culvert
Struct_Dtl	
Struct_Mtl	
Struct_Shp	
Jurisd_ID	06073C_118
Plan_ID	06073C_06073C_FIRM1
Diameter	0
Length	110
Width	0
Height	10
US_Invert	0
DS_Invert	0
RD_EL_NAVD	41.9
Loc_Descr	Qualcomm Way
Other	Info from FEMA NFHL shapefile data/FIS FP V.9-350P

Watershed Management Area Streams with Channel Structures

Carlsbad Watershed - HU 904.00, 211 mi2

Exhibit Date: Sept. 8, 2014

Geosyntec consultants

RICK ENGINEERING COMPANY

Attachment B

Hydromodification Management Applicability/Exemptions

ATTACHMENT B.1

TEXT AND HMP EXEMPTION EXHIBITS EXCERPTED FROM: "HYDROMODIFICATION EXEMPTION ANALYSES FOR SELECT CARLSBAD WATERSHEDS," PREPARED BY CHANG CONSULTANTS, DATED JUNE 10, 2013

HYDROMODIFICATION EXEMPTION ANALYSES FOR SELECT CARLSBAD WATERSHEDS

June 10, 2013

REGISTERED PROFESSIONAL ENGINEER
WAYNE W. CHANG
No. 46548
Exp. 6/30/13
CIVIL
STATE OF CALIFORNIA

Wayne W. Chang, MS, PE 46548

Chang Consultants
Civil Engineering ◦ Hydrology ◦ Hydraulics ◦ Sedimentation

P.O. Box 9496
Rancho Santa Fe, CA 92067
(858) 692-0760

Merkel & Associates, Inc.

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City of Carlsbad
Report accepted by:

Glen K. Van Peski

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Glen K. Van Peski, Engineering Manager — Date
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EXECUTIVE SUMMARY

This Executive Summary provides an initial synopsis for readers that merely want information on whether a project qualifies for a hydromodification exemption. The synopsis is followed by a more detailed summary of the hydromodification criteria and report findings.

Synopsis

The City of Carlsbad's current storm water standards requires Priority Development Projects to incorporate treatment control best management practices with flow-control requirements to address hydromodification. Projects may be relieved from this requirement if it meets defined hydromodification exemption criteria. This report has studied select areas within the city tributary to Agua Hedionda Lagoon, Batiquitos Lagoon, and Buena Vista Lagoon to determine if the exemption criteria is met. The HMP Exemption Exhibit in the map pocket at the back of this report identifies the exempt areas by hatching. If a project is within a hatched area, it qualifies to be exempt from hydromodification requirements. Projects that qualify for hydromodification exemption must still satisfy all other storm water standards (i.e.: treatment control best management practices, low impact development, and source control measures, etc.).

Detailed Summary

The City of Carlsbad (City) adopted their latest updated *Standard Urban Stormwater Management Plan* (SUSMP) on January 14, 2011. The SUSMP was in response to additional requirements associated with a reissuance of the San Diego Regional Water Quality Control Board's municipal stormwater permit (Order No. 2007-01). One important requirement was the adoption of the final *Hydromodification Management Plan*, dated March 25, 2011 (final HMP). The final HMP was approved by the San Diego Copermittees and approved by the Regional Water Quality Control Board by Resolution R9-2010-0066.

According to the SUSMP, development and redevelopment projects are subject to either Standard Stormwater or the more rigorous Priority Development Project (PDP) requirements. The City's "Storm Water Standards Questionnaire E-34" (see Figure 11) is used to determine whether a project must meet Standard Stormwater or PDP requirements. In general, PDP projects include new subdivisions with 10 or more dwelling units, commercial/industrial development greater than an acre, automotive repair shops, restaurants, hillside development, development impacting Environmentally Sensitive Areas, parking lots, streets, roads, highways, retail gasoline outlets, projects affecting the Coastal Development Zone, and projects that disturb more than 1 acres. The questionnaire provides specific thresholds under which these new development types fall within PDP requirements as well as separate redevelopment criteria.

Projects subject to PDP requirements must include treatment control best management practices (BMPs) and are required to incorporate hydromodification BMPs. Treatment control BMPs filter and remove pollutants from stormwater and have existed for several years in various forms. Hydromodification is essentially a new requirement whose purpose is to control post-development storm water runoff rates, velocities, and durations in order to maintain or reduce pre-development downstream erosion, sediment pollutant generation, and protect beneficial uses and stream habitat (an interim hydromodification requirement was in place prior to the current SUSMP, but was dissimilar to the current requirement in many aspects). Hydromodification BMPs must accomplish these goals for flows ranging from a fraction of the 2-year event (10, 30, or 50 percent) to the 10-year event. The goals are generally met by deploying certain BMPs that store and infiltrate storm runoff such as bioretention basins, vaults, cisterns, flow-through planters, infiltration facilities, etc.

However, the final HMP outlines potential scenarios where, if certain projects qualify, could be exempt from satisfying hydromodification requirements (HMP exemptions). It should be noted that a project exempt from hydromodification is still subject to treatment control and the Standard Stormwater requirements. To determine HMP status on projects subject to PDP requirements, applicants are required to complete the HMP (Hydromodification Management Plan) Applicability Determination (see Figure 12), which identifies the potential exemptions from hydromodification requirements.

Depending on a project's location within the city, some of the exemption criteria could require a project proponent to undertake significant engineering analyses and evaluation of downstream drainage facilities and conditions. Consequently, the City of Carlsbad's Land Development Engineering Division has commissioned this hydromodification exemption study. A focus was made to look at the three lagoons within the city (Buena Vista, Agua Hedionda, and Batiquitos Lagoon) and, using the final HMP guidelines, explore applicable HMP exemptions. This study assesses the lagoons and seven (7) major drainage areas contributing to the lagoons to determine whether they meet certain hydromodification exemption criteria. HMP exemptions will assist small developments that may not have the resources to undertake downstream engineering analyses, but would qualify for a hydromodification exemption. Medium and large developments will also benefit from this study. The seven major drainage areas are tributary to one of the seven following storm drain outlets into Buena Vista, Agua Hedionda, or Batiquitos Lagoon (see the Study Area Exhibits and HMP Exemption Exhibit in the map pocket):

Buena Vista Lagoon

- 48" and 66" outlets on the east side of Carlsbad Boulevard into the south side of the lagoon
- 48" outlet on the west side of Interstate 5 into the south side of the lagoon
- 66" outlet on the west side of Jefferson Street into the south side of the lagoon

Agua Hedionda Lagoon

- 18" outlet on the west end of Date Avenue into the north side of the lagoon
- 84" outlet on the east side of the railroad tracks into the north side of the lagoon
- 60" outlet near the south end of Marina Drive into the north side of the lagoon

Batiquitos Lagoon

- 84" outlet on the east side of Carlsbad Boulevard into the north side of the lagoon

Each of these major drainage areas is served by a network of public drainage facilities that outlet into a lagoon. The majority of the public facilities are underground storm drain systems or paved streets. Some facilities are also lined (concrete, gunite, etc.) drainage ditches or swales. As long as a project discharges into a non-erodible drainage network that is continuous to a lagoon outlet, it is potentially eligible for a hydromodification exemption. A development or redevelopment project can have several discharge locations, so the exemption only applies to the portion of the project that meets this criteria. The Study Area Exhibits contain the non-erodible drainage networks. It is evident from the exhibits that each major drainage area contains a continuously non-erodible network that serves a majority of the drainage area.

For each of the seven drainage areas, this report covers HMP exemption criteria using Nodes 2, 6, 7, and 8 from the HMP Applicability Determination flow chart (see Figure 12), as appropriate. This report analyzes each of these nodes for each of the seven drainage areas.

Based on the results of this study, using Node 7 of the HMP exemption criteria, Buena Vista Lagoon can be characterized as a "stabilized conveyance system" that discharges to an exempt system (i.e., the Pacific Ocean). Using rational method analyses and as-built research, the existing storm drain network collecting run-off for all of the Buena Vista Lagoon drainage areas (Major Drainage Basins 100, 200, and 300 as shown on the Study Area Exhibits) analyzed in this report have been shown to be adequate to convey the Q_{10} runoff (Node 8 criteria). Each outlet structure was observed to ensure they include adequate energy dissipation to address erosion potential, i.e., the Node 2 criteria was met for each outlet. For details of how these each of these criteria where satisfied, refer to the Technical Appendices of this study. The select areas draining to the Buena Vista Lagoon, which are determined to be exempt from HMP are shown in the HMP Exemption Exhibit.

Although Major Drainage Basin 200 meets several required criteria as discussed in the prior paragraph, the 48" outlet carrying the flow from the major basin outlets some distance from the waters edge of Buena Vista Lagoon. Based on a field review by the City Engineer, this intervening ground is densly vegetated and or naturally armored. The City Engineer found no evidence of erosion at or near the waters edge of the lagoon. Consequently, this area is identified as exempt on the HMP Exemption Exhibit.

Using Node 6 of the HMP exemption criteria, Agua Hedionda Lagoon and Batiquitos Lagoon were evaluated since they are tidally-influenced, having open stabilized connections to the Pacific Ocean. Certain drainage areas that drain to these lagoons were selected (Major Drainage Basin 400, 500, 600, and 700 as shown on the Study Area Exhibits). The existing storm drain network for each drainage area was also evaluated against their ability to carry the Q10. The storm drain system for each drainage areas has the capacity to carry the Q10. The outlet for each storm drain system was also observed to ensure they include adequate energy dissipation to address erosion potential, i.e., the Node 2 criteria was met for each outlet. For details of how these each of these criteria where satisfied, refer to the Technical Appendices of this study. The select areas draining to Agua Hedionda Lagoon and Batiquitos Lagoon which are determined to be exempt from HMP are shown in the HMP Exemption Exhibit.

There are two isolated areas within Major Drainage Basin 600 that direct storm runoff over the natural ground surface west of the railroad tracks. Since naturally-lined swales prevent a hydromodification exemption, these areas are not identified as exempt on the HMP Exemption Exhibit. It will be the responsibility for future development projects in the non-exempt areas west of the tracks to assess the situation. It is possible that the development will have to include hydromodification best management practices, or propose drainage improvements that eliminate the naturally-lined swales in order to qualify for a hydromodification exemption.

INTRODUCTION

The City of Carlsbad (City) adopted their latest updated *Standard Urban Stormwater Management Plan* (SUSMP) on January 14, 2011. The SUSMP was in response to additional requirements associated with a reissuance of the San Diego Regional Water Quality Control Board's municipal stormwater permit (Order No. 2007-01). One important requirement was the adoption of the final Hydromodification Management Plan, dated March 25, 2011 (final HMP). The final HMP was approved by the San Diego Copermittees and approved by the Regional Water Quality Control Board by Resolution R9-2010-0066.

According to the SUSMP, development and redevelopment projects are subject to either Standard Stormwater or the more rigorous Priority Development Project (PDP) requirements. The City's "Storm Water Standards Questionnaire E-34" (included following the report figures) is used to determine whether a project must meet Standard Stormwater or PDP requirements. In general, PDP projects include new subdivisions with 10 or more dwelling units, commercial/industrial development greater than an acre, automotive repair shops, restaurants, hillside development, development impacting Environmentally Sensitive Areas, parking lots, streets, roads, highways, retail gasoline outlets, projects affecting the Coastal Development Zone, and projects that disturb more than 1 acres. The questionnaire provides specific thresholds under which these new development types fall within PDP requirements as well as separate redevelopment criteria.

Projects subject to PDP requirements must include treatment control best management practices (BMPs) and are required to incorporate hydromodification BMPs. Treatment control BMPs filter and remove pollutants from stormwater and have existed for several years in various forms. Hydromodification is essentially a new requirement whose purpose is to control post-development storm water runoff rates, velocities, and durations in order to maintain or reduce pre-development downstream erosion, sediment pollutant generation, and protect beneficial uses and stream habitat (an interim hydromodification requirement was in place prior to the current SUSMP, but was dissimilar to the current requirement in many aspects). Hydromodification BMPs must accomplish these goals for flows ranging from a fraction of the 2-year event (10, 30, or 50 percent) to the 10-year event. The goals are generally met by incorporating site design measures to balance the use of pervious and impervious areas, and by using BMPs that store and infiltrate storm runoff such as bioretention basins, vaults, cisterns, flow-through planters, infiltration facilities, etc.

However, the final HMP outlines potential scenarios where, if certain projects qualify, could be exempt from satisfying hydromodification requirements (HMP exemptions). The SUSMP provides for hydromodification exemptions under certain conditions. To determine HMP status on projects subject to PDP requirements, applicants are required to complete the HMP (Hydromodification Management Plan) Applicability Determination (see Figure 12), which identifies the potential exemptions from hydromodification requirements.

Depending on a project's location within the city, some of the exemption criteria could require a project proponent to undertake significant engineering analyses and evaluation of downstream drainage facilities and conditions. Consequently, the City of Carlsbad's Land Development Engineering Division has commissioned this hydromodification exemption study. A focus was made to look at the three lagoons within the city (Buena Vista, Agua Hedionda, and Batiquitos Lagoon) and, using the final HMP guidelines, explore applicable HMP exemptions. This study assesses the lagoons and seven (7) major drainage areas contributing to the lagoons to determine whether they meet certain hydromodification exemption criteria. HMP exemptions will assist small developments that may not have the resources to undertake downstream engineering analyses, but would qualify for a hydromodification exemption. Medium and large developments will also benefit from this study. The seven major drainage areas are tributary to one of the seven following storm drain outlets into Buena Vista, Agua Hedionda, or Batiquitos Lagoon (see the Study Area Exhibits and HMP Exemption Exhibit in the map pocket):

Buena Vista Lagoon

- 48” and 66” outlets on the east side of Carlsbad Boulevard into the south side of the lagoon
- 48” outlet on the west side of Interstate 5 into the south side of the lagoon
- 66” outlet on the west side of Jefferson Street into the south side of the lagoon

Agua Hedionda Lagoon

- 18” outlet on the west end of Date Avenue into the north side of the lagoon
- 84” outlet on the east side of the railroad tracks into the north side of the lagoon
- 60” outlet near the south end of Marina Drive into the north side of the lagoon

Batiquitos Lagoon

- 84” outlet on the east side of Carlsbad Boulevard into the north side of the lagoon

Each of these major drainage areas is served by a network of public drainage facilities that outlet into a lagoon. The majority of the public facilities are underground storm drain systems or paved streets. Some facilities are also lined (concrete, gunite, etc.) drainage ditches or swales. As long as a project discharges into a non-erodible drainage network that is continuous to a lagoon outlet, it is potentially eligible for a hydromodification exemption. A development or redevelopment project can have several discharge locations, so the exemption only applies to the portion of the project that meets this criteria. The Study Area Exhibits contain the non-erodible drainage networks. It is evident from the exhibits that each major drainage area contains a continuously non-erodible network that serves a majority of the drainage area.

For each of the seven drainage areas, this report covers Nodes 2, 6, 7, and 8 from the HMP Applicability Determination flow chart (see Figure 12), as appropriate. The following sections analyze each of these nodes for each of the seven drainage areas. Nodes 1, 3, and 4 apply to most new development projects and are project-specific requirements, so they are not analyzed in this report. It is likely that a redevelopment project could be exempt from hydromodification under Nodes 3 and 4 if it is not increasing the pre-redevelopment impervious area. Node 5 only applies to projects within the city that discharge directly to the Pacific Ocean and is not analyzed in this report. Nodes 9 through 14 are project-specific requirements that are not analyzed in this report.

ENERGY DISSIPATION

Node 2 from the HMP Applicability Determination flow chart requires properly designed energy dissipation for stormwater outfalls to an unlined area. Since the storm drain networks considered in this report are continuously non-erodible to one of the three lagoons, the energy dissipation to be studied are at the lagoon outlets. As-built drawings were reviewed and a site visit was performed to determine the conditions at each outlet. The following describes the findings for each outlet.

Buena Vista Lagoon 48" and 66" Outlets
These are adjacent reinforced concrete pipe outlets that discharge into the south edge of Buena Vista Lagoon immediately east of the merge of State Street and Carlsbad Boulevard. During the site visit, the lagoon water level was at the invert of the 48" outlet and just above the invert of the 66" outlet (see Figure 1 after this report text). Riprap energy dissipation was not observed below the outlets nor was there evidence of erosion below the outlets (see Figure 2).

Drawing No. 215-9 shows that the invert elevation of the 66" reinforced concrete pipe outlet is at 6.0 feet NGVD 29 (the reference drawings are included on the compact disc in the map pocket). The 48" outlet is shown on Drawing 153-9, but the plan does not identify the vertical datum. Based on the site visit, the 48" outlet invert is approximately 6 inches higher than the 66" outlet invert. Buena Vista Lagoon contains a weir structure near the Pacific Ocean that controls the water surface in the lagoon. A field survey by Algert Engineering revealed that the top of the weir structure is at 7.6 feet NAVD 88 or 5.5 feet NGVD 29. Therefore, the water level in the lagoon will be within at least 6 to 12 inches of the outlets. During most periods, the water level should be higher than 5.5 feet due to natural sand build-up above the weir crest caused by littoral processes as well as backwater in the lagoon. Since ponded water is an effective energy dissipater, the 48" and 66" outlets contain proper energy dissipation. This is further evidenced by the absence of erosion below the outlets even though they have been in place since at least the mid-1980's.

Buena Vista Lagoon 48" Outlet
This 48" reinforced concrete pipe is a Caltrans facility whose outlet discharges towards, but not directly into, the south edge of Buena Vista Lagoon immediately west of Interstate 5. The as-built plans (Document No. 40002483) show that the outlet is at elevation 22.0 feet and was designed with "rock slope protection." During the site visit, riprap was observed below the 48" outlet (see Figure 3). The typical riprap diameter was over 12 inches, which is consistent with the sizing proposed on the design plans. Tall grasses obscured some of the riprap, but the grass indicates that the energy dissipation is effective. If the riprap was not effective, then eroded earth would be visible below the outlet rather than grass.

Buena Vista Lagoon 66" Outlet
This 66" reinforced concrete pipe discharges into the south edge of Buena Vista Lagoon immediately west of Jefferson Street. The as-built plans (Drawing No. 182-10) show that the outlet invert is at elevation 5.3 feet NGVD 29 and contains ¼-ton riprap. The outlet invert was just below the lagoon water level (see Figure 4) during the site visit, which is consistent with the weir-controlled lagoon water level. Riprap was not observed at the outlet during the site visit due

to the difficulty in accessing the outlet through the dense vegetation. However, the fact that the water level will be at or above the outlet invert indicates that this outlet has appropriate energy dissipation.

Agua Hedionda Lagoon 18" Outlet

This 18" corrugated metal pipe discharges onto a riprap-lined revetment protecting the northeast bank of Agua Hedionda Lagoon immediately west of the intersection of Date Avenue with Garfield Street (see Figure 5). Storm runoff flows a short distance down the revetment and into the lagoon. As-built plans were not available for the outlet, but the average riprap diameter is larger than the pipe diameter, so it is obvious that riprap at the outlet provides appropriate energy dissipation from the outlet to the lagoon for the full range of flows in the pipe. In addition, the tributary drainage area covers approximately 5.2 acres, so the pipe flows will be relatively small.

Agua Hedionda Lagoon 84" Outlet

This 84" reinforced concrete pipe discharges into the north edge of Agua Hedionda Lagoon just east of the railroad tracks. The engineering plans (Drawing No. 360-5) were as-built in 2006, so this is a relatively recent system. The plans show that the storm drain system and its grouted riprap energy dissipater were designed for the 100-year storm flow in accordance with current engineering criteria. A site visit confirmed that the grouted riprap energy dissipater exists and is in substantial conformance with the plans (see Figure 6).

Agua Hedionda Lagoon 60" Outlet

This 60" reinforced concrete pipe discharges directly into the north edge of Agua Hedionda Lagoon just west of Marina Drive. The as-built plans (Drawing No. 152-3) show that the outlet invert elevation is -1.75 feet NGVD 29. This elevation is lower than mean sea level, so the lagoon water level will serve as appropriate energy dissipation for the outflow. A site visit confirmed that the invert is lower than the lagoon water level (see Figure 8).

Batiquitos Lagoon 84" Outlet

This 84" reinforced concrete pipe discharges into the north edge of Batiquitos Lagoon just east of Carlsbad Boulevard and west of the railroad tracks. The as-built drawings (Drawing No. 337-9) show that the storm drain system and its energy dissipater (1-ton riprap and concrete sill) were designed for the 100-year storm flow in accordance with current engineering criteria. A site visit confirmed that the energy dissipater exists in substantial conformance with the plans (see Figure 9).

Summary

The above information confirms that proper energy dissipation currently exists at each of the storm drain outlet locations for the seven major drainage areas. The dissipation is provided by either riprap or the water level in a lagoon. Therefore, each outlet satisfies Node 2 from the HMP Applicability Determination flow chart.

LAGOON ASSESSMENTS

Discharge to Lagoon Area

Node 6 from the HMP Applicability Determination is based on whether a project discharges directly to a lagoon area. All seven of the major drainage areas discharges to a lagoon. However, the lagoon must be tidally-influenced to satisfy Node 6. A lagoon is tidally-influenced if it falls below the mean higher-high water tidal level. Of the three lagoons, Agua Hedionda Lagoon and Batiquitos Lagoon have permanent openings to the Pacific Ocean, so are tidally-influenced during and below mean higher-high water. Buena Vista Lagoon is outlet controlled with a weir above the mean higher-high water tidal level that prevents tidal influence within the lagoon.

Node 6 also requires an assessment of the freshwater/saltwater balance and the resultant effects on lagoon-system biology. Merkel & Associates, Inc. has performed this assessment for the outlets to the two tidally-influenced lagoons, as discussed below. Their assessment concludes that the effects of exempting these outlets from hydromodification associated with lagoon biology at the four tidally influenced sites are negligible or within acceptable limits. Much of the evaluation performed by Merkel & Associates, Inc. is based on the firm's extensive experience working within all of the Carlsbad lagoons over the past two decades. This work has included completion of 12 years of biological and physical monitoring within Batiquitos Lagoon from 1997 through 2009, conducting multiyear biological and water quality investigations within Agua Hedionda Lagoon, as well as eight years of intensive field work from 2000 to 2008 in Agua Hedionda Lagoon to eradicate the invasive alga *Caulerpa taxifolia* from the lagoon. In addition, a site visit was made to each of the outlets in support of the present analysis.

The two fully tidal lagoons within the city of Carlsbad are not particularly susceptible to adverse effects of changing freshwater/saltwater balances due to broad-scale characteristics of the lagoons including relatively extensive subtidal basins, well-established channels, and permanently opened lagoon mouths. For this reason, evaluations of the various drains under the Node 6 requirement has focused on consideration of the site specific characteristics at the drains that could potentially result in localized effects. These effects were assessed in the broader context of lagoon biology and considering other areas within the lagoons with greater freshwater inflow. Prolonged flows into the two lagoons from Agua Hedionda Creek, San Marcos Creek, and Encinitas Creek often result in intermittent, seasonally depressed salinities. However, beyond the localized points of discharge, these creek flows have not resulted in permanent shifts in biology from the tidally dominated marine communities to freshwater or even brackish communities. This resistance to community shifts at the mouths of the larger creeks discharging to the lagoons has been used for contextual reference in assessing the potential risk of a localized community shift due to potential changes in the freshwater/saltwater balance at each outlet under consideration.

- *Agua Hedionda Lagoon 18" Outlet*

This 18" corrugated metal pipe discharges onto the riprap-lined shoreline, immediately east of the ocean inlet to the west (outer lagoon) basin. Storm runoff leaves the pipe above the mean higher-high water level and therefore discharges onto bare rock, above the upper boundary for marine species (Figure 5). Below the pipe, the intertidal riprap is occupied by typical marine species, including barnacles (*Chthamalus* and *Balanus* spp.), lined shore crabs (*Pachygrapsus* *crassipes*), and various species of algae, primarily *Sargassum muticum*, a non-native brown alga common in the basin. The subtidal environment is fully marine (saltwater), with fish species such as topsmelt (*Atherinops affinis*) and garibaldi (*Hypsypops rubicundus*) common around the riprap at this location. Low nuisance flow from the outlet is minimal, and storm runoff discharged from the pipe is low (estimated to be 5.9 cfs for a 10-year storm) and is dispersed by the riprap and quickly mixed into the water column by the strong currents that pass along the shoreline as part of the diurnal tidal exchange.

The watershed for this discharge is currently 5.19 acres, with a 10-year storm flow volume of 0.35 acre-feet. The watershed is currently built-out, therefore there is no future increase in storm discharge to be evaluated and no change to the freshwater/saltwater balance will occur.

- *Agua Hedionda Lagoon 84" Outlet*

This 84" pipe discharges into the northwest corner of the central basin (middle lagoon) of Agua Hedionda Lagoon onto a grouted riprap energy dissipater apron. There is some opportunistic exotic freshwater vegetation growing in accumulated debris and sediment on the grouted floor of the dissipater (*Cyperus alternifolius* and *Washingtonia robusta*), supported by the perennial low flow of freshwater from surrounding irrigation runoff (Figure 6). The discharge then flows from the dissipater into either open water at higher tides or onto unvegetated mudflat at lower tides (Figure 7). There is no salt marsh vegetation or eelgrass (*Zostera marina*) present at the discharge point, although eelgrass occurs within deeper subtidal waters further out in the basin. The mudflat below the discharge point is littered with rock debris supporting limited marine growth. Some geosynthetic fabric has become exposed from beneath previously placed revetment stone. This fabric similarly supports limited marine growth. The mudflat is expected to supports a community of typical euryhaline infaunal invertebrates adapted to a range of salinities due to the perennial low flows of freshwater from the outlet that cross the mudflat under low tide conditions. Given the westerly location of the drain outlet and the well flushed nature of the central basin of the lagoon, subtidal and water column species are expected to be typical of fully marine environments.

This region of the lagoon is relatively near to the ocean inlet, is well-flushed by tidal waters, and is not prone to salinity depression. The basin into which the drain discharges is fairly small at approximately 19 acres and connects to the inner and outer lagoon basins via a large, fast flowing main channel located along the southern edge of the basin. Beyond a relatively narrow intertidal mudflat, the basin slopes steeply to the lagoon bottom. Because of the strong channel flows, the middle lagoon basin develops a moderate gyre during tidal exchanges thus enhancing flushing of this basin. Incoming low flows from this drain float as a freshwater lens on top of the fully marine waters of the basin. More substantial storm flows are expected to generate localized mixing and depressions in salinity due to the discharge velocities to the tidal waters. Given the efficiency of tidal circulation in the area of the drain, the depression of salinity is expected to be short in duration and followed by rapid return of salinity characteristics exhibited lagoon-wide.

Pulsed reductions in salinity are a normal condition in coastal lagoons and the marine life that occurs in lagoon habitats are well adapted to tolerate much wider variations in salinity that those resulting from this relatively small contributor to the system. Due to the substantial lagoon scale and variety of habitats present in the lagoon, motile marine fish and invertebrate species have opportunities to seek refuge from sub-optimal salinity conditions away from the most depressed salinity environments near the drain. For infaunal organisms, pulsed salinity depression are typically managed by a shutdown of activities (e.g., closing shells on mollusks, cessation of water pumping for crustaceans and many annelid worms), or seeking shelter in the mud away from depressed salinity flows.

The watershed for this discharge is mostly built out. Future build out is estimated to increase the 10-year storm flow volume by up to approximately 3 percent, from 26.14 to 26.95 acre-feet. Increasing the 10-year storm flow volume by approximately 3 percent would have an insignificant effect on the freshwater/saltwater balance of the basin, given the large volume of tidal water that is efficiently exchanged in this area. The resultant effects on lagoon-system biology would also be insignificant due to the absence of vegetation at the discharge, the availability of alternative adjacent waters for motile marine species, and the adaptability of lagoon species to much higher variations in salinity than those resulting from storm flow at this drain under current or anticipated future conditions.

- *Agua Hedionda Lagoon 60" Outlet*

This 60" reinforced concrete pipe discharges into the east basin of Agua Hedionda Lagoon at an outlet invert elevation below mean sea level, as discussed above. Therefore storm flows discharge primarily into the open water, or occasionally onto the concrete apron below the pipe during extreme low tides (Figure 8). The shoreline surrounding the outlet is armored by small rocks with very limited marine growth. There is no marsh vegetation or eelgrass immediately at the outlet, although eelgrass occurs within the subtidal areas beyond the immediate discharge point and outside of the existing sediment delta extending outward from the outlet. There appears to be perennial low flow of freshwater from the outlet although it is difficult to discern the nature and scale of the flows given the subtidal invert of the pipe.

This region of the lagoon is fully tidal, though it experiences infrequent periods of depressed salinity as a result of its proximity to Agua Hedionda Creek at the head of the lagoon. Localized depressions in salinity during storm flow from the 60" outlet are well within the salinity range experienced by most of the east basin of the lagoon and are not as severe as the variability observed at the mouth of Agua Hedionda Creek. The sessile marine life at the discharge point is tolerant of variations in salinity due to the chronic low flow of freshwater from the outlet and periods of depressed salinity from storm events. The motile marine life occurring in the area is well adapted to rapid, pulsed variations in salinity, but can also make use of alternate regions of the lagoon closer to the lagoon mouth or in deeper waters to avoid sub-optimal salinity conditions, when required.

The watershed for this discharge is mostly built out. Future build out could potentially increase the 10-year storm flow volume by up to approximately 3 percent, from 31.59 to 32.57 acre-feet. Increasing the 10-year storm flow volume by approximately 3 percent would have an insignificant effect on the freshwater/saltwater balance of the basin, given the mixing effect of the tidal exchange and the much larger effect of nearby Agua Hedionda Creek during storm flows. The resultant effects on lagoon-system biology would also be insignificant, due to the absence of vegetation at the discharge, the availability of alternative adjacent waters for motile marine species, and the adaptability of lagoon species to much higher variations in salinity than those resulting from storm flow at this drain.

- *Batiquitos Lagoon 84” Outlet*

This 84” reinforced concrete pipe discharges into the northwest corner of the west basin of Batiquitos Lagoon, immediately inside the lagoon ocean inlet. After leaving the concrete and riprap dissipater, stormwater flows into open tidal waters at high tides or onto unvegetated sand flats at low tide (Figures 9 and 10). There is no marsh vegetation or eelgrass present in the vicinity of the outlet. The drain perennially discharges low flow freshwater from the surrounding developments through a small detention/water quality basin. Under some low tide and flow conditions, the freshwater flow extends fully to the tidal waters of the lagoon while at other times the flows dissipate into the sand prior to reaching the low tide waterline. As a result, the benthic invertebrate community in the immediate vicinity of the low flow channel thalweg across the sand flats are likely adapted to variations in the salinity of the surface flow at low tides. Because of the shifting sand nature of the discharge environment, most infaunal organisms found here are motile and have the capacity to retreat to more favorable areas if needed to avoid undesirable salinity environments. Most organisms also have the capacity to behaviorally adapt to short-term hyposalinity exposure during low tide periods at the immediate outlet point.

This region of the lagoon is fully tidal and very well mixed due to its proximity to the ocean inlet and the high flow rates resulting from diurnal tidal exchanges. Storm runoff discharged from the pipe is relatively low (estimated to be 15.84 acre-feet for a 10-year storm) and is quickly mixed by the tidal exchange during either an ebb or flood tide condition.

The watershed for this discharge is mostly built out. Future build out is estimated to increase the 10-year storm flow volume by up to approximately 15 percent, from 15.84 to 18.21 acre-feet. Increasing the 10-year storm flow discharge by approximately 15 percent would have an insignificant effect on the freshwater/saltwater balance of the basin, given the large volume of tidal water exchanged in this area and the lack of residence time for storm water flows. The resultant effects on lagoon-system biology would also be insignificant, due to the absence of vegetation at the discharge, the availability of alternative adjacent waters for motile marine species, and the adaptability of lagoon species to much higher variations in salinity than those resulting from storm flow at this drain.

Finally, the Node 6 criteria requires an energy dissipation system designed to mitigate 100-year outlet velocities based on a free outfall condition. As mentioned previously, the 18” and 84” outlets into Agua Hedionda Lagoon and the 84” outlet into Batiquitos Lagoon have sufficient riprap energy dissipation for the 100-year free outflow. The 60” outlet into Agua Hedionda Lagoon is below the lagoon water level so this also has sufficient natural energy dissipation.

Stabilized Conveyance to Exempt System

Buena Vista Lagoon is not tidally-influenced so its storm drain outlets do not qualify under Node 6. The weir structure near the lagoon mouth at the Pacific Ocean has a crest elevation of 7.6 feet NAVD 88 according to a field survey by Algert Engineering. The mean higher-high water level from the nearest tidal gage at Scripps Pier in La Jolla is 5.14 feet NAVD 88. Since the mean higher-high water is lower than the weir crest, the weir prevents Buena Vista Lagoon from being tidally-influenced.

Although Buena Vista Lagoon does not qualify for the HMP_ exemption under Node 6, the lagoon can still qualify under Nodes 7 and 8. Node 7 covers stabilized conveyances to an exempt system (i.e., to the Pacific Ocean). Node 7 requires that the stabilized conveyance be a rehabilitated stream system. Buena Vista Lagoon is California's first ecological reserve and is owned by the California Department of Fish and Game. Since 1981, the Buena Vista Lagoon Foundation has conserved and restored the lagoon's marsh and wetlands and worked at stabilizing its drainage basin. Therefore, Buena Vista Lagoon is considered to be a rehabilitated system. Node 7 also requires the conveyance continue uninterrupted to the exempt system, i.e., the rehabilitated system cannot discharge to an unlined, non-engineered channel segment prior to discharge to the exempt system. Buena Vista Lagoon meets this criteria since it connects directly to the Pacific Ocean from each of the outlets.

Node 8 requires that the conveyance system has capacity to convey the 10-year ultimate condition flow. Dokken Engineering prepared detailed hydraulic analyses of Buena Vista Lagoon as part of their February 2008, *Interstate 5 North Coast Floodplain Studies.* The hydraulic analyses were performed using the HEC-RAS model based on April 2004 NAVD 88 topographic mapping, as-built information for the existing bridges (NCTD railroad, Carlsbad Boulevard, and Interstate 5), and FEMA's 100-year flow rates. The FEMA 100-year flow rates are greater than the 10-year ultimate condition flow, so the 100-year results will be more conservative than the 10-year ultimate condition results. Dokken's existing condition 100-year HEC-RAS results are included in Appendix A. The results show that the 100-year floodplain is generally within the lagoon, so the 10-year flow will be conveyed in the lagoon. The results also indicate that most of the 100-year flow velocities are less than 6 feet per second, which is the typical threshold for erosive velocities. The only locations with velocities greater than 6 feet per second are at the Interstate 5 bridge and near the weir. However, these areas contain riprap to resist the high velocities. Based on Dokken's detailed hydraulic analysis, Buena Vista Lagoon satisfies Node 8.

Summary

The four drainage areas tributary to Agua Hedionda Lagoon and Batiquitos Lagoon qualify for Node 6 from the HMP Applicability Determination flow chart since these lagoons meet the tidally-influenced criteria. The easterly and westerly drainage areas tributary to and outletting directly into Buena Vista Lagoon qualify for Nodes 7 and 8 because Buena Vista Lagoon is a stabilized conveyance to the Pacific Ocean with capacity for the ultimate condition 10-year flow and not subject to erosion. The City Engineer has determined, based on field review, that the middle drainage area tributary to Buena Vista Lagoon qualifies for an exemption because the densly vegetated and/or naturally armored habitat between the storm system outfall and the waters edge functions as an extension of the stabilized conveyance. The City Engineer found no evidence of erosion at or near the point where the discharge intersects the waters edge of the lagoon.

HYDROLOGIC AND HYDRAULIC ANALYSES

As mentioned in the Introduction, hydromodification applies to flows up to the 10-year event. Consequently, the drainage network (storm drain pipes, streets, etc.) within each major drainage area are required to convey the 10-year flow in order to qualify for an exemption. All of the available as-built plans for the public storm drain systems in the seven major drainage areas were obtained and reviewed. Several of the more recent as-built plans list 10- or 100-year flow rates in the pipes and/or hydraulic grade lines on the storm drain profiles. These systems have been identified on the Study Area Exhibits and further analyses were not required since the systems have been designed to convey the 10-year or greater flow rates. Therefore, development within these areas is exempt from HMP.

Hydrologic and hydraulic analyses have been performed for the remaining systems whose plans do not contain the flow or hydraulic grade line data. The hydrologic analyses were performed to determine the ultimate condition 10-year flow rates. The County of San Diego's 2003 *Hydrology Manual* rational method procedure was used for the 10-year hydrologic analyses. The rational method input parameters are summarized below and the supporting data is included in Appendix B:

- Precipitation: The 10-year, 6- and 24-hour precipitation values are 1.7 and 3.1 inches, respectively, for the drainage areas tributary to Buena Vista and Agua Hedionda Lagoon. The 10-year, 6- and 24-hour precipitation values are 1.7 and 2.9 inches, respectively, for the drainage areas tributary to Batiquitos Lagoon.

- Drainage subbasin: The drainage subbasins were delineated from the City's 2005 2-foot contour interval topographic mapping, the City's GIS storm drain network, available as-built plans, and a site investigation. See the Study Area Exhibits in the map pocket for the major and subbasin boundaries, rational method node numbers, and subbasin areas.

- Hydrologic soil groups: The hydrologic soil groups were determined from the *San Diego County Soils Interpretation Study* maps for Encinitas and Rancho Santa Fe. The soil group in the study area is primarily A with some pockets of C and D.

- Runoff coefficients: The runoff coefficients were assigned based on the underlying land uses and soil groups. The land uses range from undisturbed areas to commercial/industrial development. The land uses were determined from a 2009 aerial photograph from the City and 2010 Google Earth aerials as well as a site investigation. For undeveloped areas that could be subject to development, a developed condition was assumed. Therefore, the hydrologic analyses essentially model a fully built-out condition. This approach is similar to what would be done for a storm water master plan.

- Flow lengths and elevations: The flow lengths and elevations were obtained from the topographic mapping and engineering plans.

The 10-year rational method analyses were performed using CivilDesign's San Diego County Rational Hydrology Program and the results are included in Appendix B. Separate analyses were performed for the major drainage areas and are labeled as follows:

Buena Vista Lagoon

- Major Basin 100 is tributary to the 48" and 66" outlet on the east side of Carlsbad Boulevard
- Major Basin 200 is tributary to the 48" outlet on the west side of Interstate 5
- Major Basin 300 is tributary to the 66" outlet on the west side of Jefferson Street

Agua Hedionda Lagoon

- Major Basin 400 is tributary to the 60" outlet at the south end of Marina Drive
- Major Basin 500 is tributary to the 18" outlet at the west end of Date Avenue
- Analyses were not performed for the 84" outlet on the east side of the railroad tracks because flow rates and hydraulic grade lines were provided on the majority of the as-built plans.

Batiquitos Lagoon

- Analyses were not performed for the 84" outlet on the east side of Carlsbad Boulevard because flow rates and hydraulic grade lines were provided on the majority of the as-built plans.

The CivilDesign rational method analyses include pipeflow routines for modeling flow in circular pipes. The upstream and downstream invert elevations and pipe length are entered in the model for each storm drain segment. The program then determines the required normal depth pipe size based on the calculated 10-year flow rate, longitudinal slope, and roughness coefficient. The pipeflow routines were used to assess the adequacy of the existing pipes. Invert elevations were selected so that the longitudinal slope from the as-built plans was accurately modeled in the analyses. The longitudinal slope of each storm drain segment was determined from a review of all relevant as-built plans. Some storm drain segments contain varying or multiple slopes. In this case, the flattest slope was used because it will result in the most conservative sizing. A few segments were missing elevations on the as-built plans. For these segments, the average street slope was used. The pipe size from the hydraulic analyses were then compared to the size from the as-built plans to identify pipes with adequate capacity and those with deficiencies.

Since the rational method program determines the minimum required pipe size to convey the 10-year flow in each specific segment, it is possible that program will show the required size increasing or decreasing in adjacent segments of the overall storm drain system. For instance, if the same flow rate is conveyed in two adjacent segments, but the downstream segment has a steeper longitudinal slope, the results can show that the downstream pipe is smaller. Engineering design criteria typically does not allow subsequent segments in a storm drain system to be smaller. However, since the rational method results are merely used as a comparison with the sizes from the as-built plans, any usual telescoping effects are no relevant.

The pipes have been categorized based on their capacity and identified on the Study Area Exhibits per their category. The first category represents pipes in which the as-built plans contain flow rate or hydraulic grade line information indicating that the pipes can convey the 10-year runoff. As mentioned above, analyses were not specifically performed for these systems since detailed information is contained on the as-built plans. The second category represents pipes in which the rational method analyses show that the existing size can convey the 10-year flow rate. The third category represents pipes in which the rational method analyses show that the existing pipes need to be upsized by at most one pipe size (6 inches) to convey the 10-year flow. The fourth category represents pipes in which the rational method analyses show that the existing pipes need to be upsized by more than one pipe size to convey the 10-year flow.

The first and second categories represent no major deficiencies in capacity. The third category indicates that the existing pipe is slightly undersized. However, if pressure flow and street capacity are considered, these systems will be capable of conveying the 10-year flows since the additional flow associated with an at most 6 inch increase in pipe size can be conveyed under pressure or within the adjacent street. This was confirmed by comparing the 10-year flow rates with a street flow capacity chart. For a given pipe segment, the street flow capacity chart indicated that the associated street can convey the required flow. Therefore, the drainage systems within the first three categories have capacity for the 10-year flow.

Existing pipes under the fourth category require additional review to determine whether the 10-year flow can be conveyed. Additional review resulted in the following assessment of the storm drain systems within the fourth category.

Major Basin 100

There are four storm drain segments in Major Basin 100 that fall within the fourth category. The segments are between rational method nodes 105 to 109, 135 to 136, 137 to 138, and 138 to 141. The following assesses the pipe and street capacity of each of these four segments.

The existing pipe from nodes 105 to 109 has an 18” diameter with a normal depth capacity of approximately 10 cubic feet per second (cfs). However, the rational method results show that the 10-year flow rate is 37 cfs, and the pipe size needed to convey 37 cfs varies from 30” to 33”. The corridor along the street between these nodes has capacity for the additional 27 cfs (37 – 10 = 27 cfs) needed beyond the pipe capacity. Therefore, the combined pipe and street in this area can convey the 10-year flow.

A similar assessment is made for the other three segments. The existing pipe from nodes 135 to 136 is a 24” reinforced concrete pipe (RCP), while the analyses show that a 33” RCP is needed. The existing pipe from nodes 137 to 138 is a 36” RCP while the analyses show that a 45” RCP is needed. The existing pipe from nodes 138 to 141 is a 12” RCP while the analyses show that a 30” RCP is needed. For each of these deficient segments, the associated streets can handle the additional capacity needs. In addition, the adjacent upstream and downstream pipe segments are not deficient. Therefore, the overall drainage systems along these nodes can convey the 10-year flow.

Major Basin 300

There are two storm drain segments in Major Basin 300 that fall within the fourth category. The segments are between rational method nodes 309 to 316 and nodes 340 to 343. The existing pipes from nodes 309 to 316 are 24” RCPs, while the required pipe varies from 36” to 39”. The existing pipes from nodes 340 to 343 are 66” RCPs, while the required size varies from 78” to 81”. For both of these areas, the associated streets can handle the additional capacity needs, so these areas can convey the 10-year flow.

Major Basin 400

There are two storm drain segments in Major Basin 400 that fall within the fourth category. The segments are between rational method nodes 408 to 409 and 418 to 420. The existing pipe between nodes 408 and 409 is an 18” RCP, while a 30” RCP is needed. This pipe crosses a sump in the street. The excess stormwater will pond in the street until it drains through the 18” RCP. Therefore, the 10-year flow will be detained in this area. In addition, there are no natural streams in the vicinity that would be subject to HMP requirements.

The existing pipe between nodes 418 and 420 is a 60” RCP that outlets into Agua Hedionda Lagoon, while the analyses show that a 72” RCP is required. However, a 60” bypass structure near the upper end of this segment can divert a portion of the runoff to a second outlet that discharges to a cove connecting to Agua Hedionda Lagoon.The as-built plans (Drawing No. 152-3) show that the bypass is controlled by stop logs. If the bypass is open, then the pipe capacity below the bypass will be sufficient for the 10-year flow. The City of Carlsbad’s Utilities Operations staff has a “Weir Wall Removal Procedure,” so the stop logs will be removed during high flow events to ensure 10-year flow capacity. Therefore, this area conveys the 10-year runoff to Agua Hedionda Lagoon.

CONCLUSION

The City of Carlsbad’s final HMP outlines conditions under which a Priority Development Project can be exempt from hydromodification requirements. The purpose of this study is to explore HMP exemptions based on the Carlsbad SUSMP and final HMP adopted by the Regional Water Quality Control Board in January and March 2011, respectively. In particular, this study examines the criteria necessary for HMP exemptions for 1) tidally-influenced lagoons and 2) stabilized conveyances to exempt systems.

These analyses have been performed for seven major drainage areas selected by the City of Carlsbad and are summarized below based on the two primary criteria that were investigated. Additional criteria must be met in addition to the primary criteria to achieve an exemption. The additional criteria is also summarized below.

Tidally-Influenced Lagoons

Agua Hedionda Lagoon and Batiquitos Lagoon are tidally-influenced, so the direct outlets into these lagoons satisfy an exemption criteria (criteria number 6 from Figure 12). Each of outlets into these two lagoons has proper energy dissipation, so the outlets meet required exemption criteria number 2. Finally, as-built plans along with hydrologic and hydraulic analyses show that the main public drainage facilities can convey the 10-year flows to the outlets. In most cases, the underground storm drain alone has capacity for the 10-year flow. In some cases, the combination of underground and overland flow is needed to convey the flow. Where overland flow occurs, the flow is primarily conveyed within improved public streets and will not occur over natural unlined streams. This satisfies the criteria to ensure the 10-year flow does not enter natural areas subject to erosion prior to reaching the ultimate drainage system outlet.

Stabilized Conveyances
Buena Vista Lagoon is not tidally-influenced, but the outlets into this lagoon meet an exemption criteria (criteria number 7) because the lagoon is a stabilized conveyance with capacity for the ultimate 10-year flow. Each of outlets into this lagoon has proper energy dissipation, so the outlets meet required exemption criteria number 2. Furthermore, the hydrologic and hydraulic analyses show that the 10-year flow is conveyed by the underground storm drain alone in most areas, and the combination of the underground storm drain and improved public streets in the remaining areas.

Future Projects
Based on the findings in this report, future projects within one of the studied drainage areas qualify for an exemption if their storm runoff is directed to a public drainage facility included in this report without being conveyed over a natural drainage course.

However, future projects in certain locations within the study area will be required to perform additional analyses prior to receiving a hydromodification exemption. These exceptions are outlined below.

The major drainage area tributary to the 84” outlet into Agua Hedionda Lagoon is bisected along its westerly side by the existing railroad tracks. Storm runoff from two areas west of the tracks will be directed to naturally-lined swales near the tracks. Since naturally-lined swales prevent a hydromodification exemption, development west of the tracks may need to replace a natural swale with a non-erodible conveyance. It will be the responsibility for a future development project west of the tracks to assess this situation in detail and propose a solution, as needed. The HMP Exemption Exhibit delineates the two non-exempt areas for reference. Hydrologic analyses have not been performed for these two areas.

GRAPHIC SCALE

300 0 300 600

1 INCH = 300 FEET

LEGEND:

- MAJOR DRAINAGE BASIN BOUNDARY
- MINOR DRAINAGE BASIN BOUNDARY (SUBBASIN)
- OVERLAND FLOW PATH
- 3.62 AC DRAINAGE BASIN AREA
- 10 RATIONAL METHOD NODE NUMBER
- EXISTING CATCH BASIN OR INLET
- EXISTING DRAINAGE DITCH OR SWALE
- MINOR EXISTING STORM DRAIN PIPE OR LATERAL
- AS-BUILT PLANS SHOWING 10-YEAR OR HIGHER FLOW CONTAINED IN EXISTING PIPE
- NORMAL DEPTH ANALYSIS SHOWING 10-YEAR FLOW CONTAINED IN EXISTING PIPE
- NORMAL DEPTH ANALYSIS SHOWING EXISTING PIPE INCREASED BY ONE PIPE SIZE (6") TO CONTAIN 10-YEAR FLOW (SEE TABLE FOR DETAILS)
- NORMAL DEPTH ANALYSIS SHOWING EXISTING PIPE INCREASED BY MORE THAN ONE PIPE SIZE TO CONTAIN 10-YEAR FLOW (SEE TABLE FOR DETAILS)
- STORM DRAIN DISCHARGES INTO NATURAL CHANNEL SO PROPOSED DEVELOPMENT WITHIN DRAINAGE AREA MUST PROVIDE PROJECT-SPECIFIC ASSESSMENT TO DETERMINE IF AN EXEMPTION IS POSSIBLE.
- OUTLET INTO LAGOON
- A PIPE SEGMENT IDENTIFIER (SEE TABLE FOR DETAILS)

PIPE SEGMENT	AS-BUILT DRAWING NO.	EXISTING FACILITY AND MINIMUM SLOPE	10-YEAR FLOW, CFS	10-YEAR FLOW CONTAINED IN PIPE UNDER PRESSURE	EXCESS 10-YEAR FLOW CONTAINED IN STREET	EXCESS 10-YEAR FLOW ENTERS ADJACENT LAGOON
A	287-2	18" RCP AT 0.5%	13	Y		
B	220-8	18" RCP (UNKNOWN SLOPE)	37		Y	
C	462-6	18" RCP AT 0.5%	13	Y		
D	137-3A	12" RCP AT 0.24%	18		Y	
E	133-9	36" RCP AT 0.76%	91		Y	
F	146-8	24" RCP AT 0.43%	57		Y	
G	CALTRANS CONTRACT 11-039724	30" RCP (UNKNOWN SLOPE)	32	Y		
H	182-10, 304-2	66" RCP AT 0.28%	293		Y	
I	166-8, 189-6, 206-2	36" RCP AT 1.60% TO 48" RCP AT 2.27%	116 TO 265	Y		
J	141-3	24" RCP AT 1.03% TO 27" RCP AT 2.30%	56 TO 104		Y	
K	146-3	18" RCP AT 1.52%	19	Y		
L	125-4	18" RCP AT 1.23%	16	Y		
M	158-6	18" RCP AT 1.00%	34		Y	
N	158-6	24" RCP AT 1.00%	39	Y		
O	167-4	24" RCP AT 2.00%	39	Y		
P	167-4	21" RCP AT 10.00% TO 24" RCP AT 2.00%	36	Y		
Q	167-5	42" RCP AT 1.00%	117	Y		
R	152-3	60" RCP AT 0.4%	263			Y

NOTE:

THE STORM DRAIN SEGMENTS IN THIS TABLE ARE ONES IN WHICH THE HYDRAULIC ANALYSES SHOW INSUFFICIENT NORMAL DEPTH CAPACITY TO CONVEY THE 10-YEAR FLOW (YELLOW AND RED LINES ON THE LEGEND). THIS TABLE INDICATES IF THE SEGMENTS HAVE CAPACITY TO CONVEY THE 10-YEAR FLOW UNDER PRESSURE. FOR SYSTEMS THAT CANNOT CONVEY THE 10-YEAR FLOW UNDER PRESSURE, THE TABLE INDICATES IF THE EXCESS FLOW CAN BE CONVEYED IN THE STREET OR WILL DIRECTLY ENTER AN ADJACENT LAGOON. ALL OF THE SEGMENTS MEET ONE OF THESE CRITERIA AND, HENCE, SATISFIES THE HYDROMODIFICATION EXEMPTION REQUIREMENT FOR CONVEYING THE 10-YEAR FLOW.

THE DRAINAGE AREAS ENCOMPASSING SEGMENTS A THROUGH L ARE ON STUDY AREA EXHIBIT SHEET 2. THE DRAINAGE AREAS ENCOMPASSING SEGMENTS M THORUGH R ARE ON STUDY AREA EXHIBIT SHEET 1.

STUDY AREA EXHIBIT

HYDROMODIFICATION EXEMPTION

AGUA HEDIONDA CREEK

DRAINAGE AREAS

SHEET 1 OF 2

BUENA VISTA CREEK
DRAINAGE AREAS

PIPE SEGMENT	AS-BUILT DRAWING NO.	EXISTING FACILITY AND MINIMUM SLOPE	10-YEAR FLOW, CFS	10-YEAR FLOW CONTAINED IN PIPE UNDER PRESSURE	EXCESS 10-YEAR FLOW CONTAINED IN STREET	EXCESS 10-YEAR FLOW ENTERS ADJACENT LAGOON
A	287-2	18" RCP AT 0.5%	13	Y		
B	220-8	18" RCP (UNKNOWN SLOPE)	37		Y	
C	462-6	18" RCP AT 0.5%	13	Y		
D	137-3A	12" RCP AT 0.24%	18		Y	
E	133-9	36" RCP AT 0.76%	91		Y	
F	146-8	24" RCP AT 0.43%	57		Y	
G	CALTRANS CONTRACT 11-039724	30" RCP (UNKNOWN SLOPE)	32	Y		
H	182-10, 304-2	66" RCP AT 0.28%	293		Y	
I	166-8, 189-6, 206-2	36" RCP AT 1.60% TO 48" RCP AT 2.27%	116 TO 265	Y		
J	141-3	24" RCP AT 1.03% TO 27" RCP AT 2.30%	56 TO 104		Y	
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L	125-4	18" RCP AT 1.23%	16	Y		
M	158-6	18" RCP AT 1.00%	34		Y	
N	158-6	24" RCP AT 1.00%	39	Y		
O	167-4	24" RCP AT 2.00%	39	Y		
P	167-4	21" RCP AT 10.00% TO 24" RCP AT 2.00%	36	Y		
Q	167-5	42" RCP AT 1.00%	117	Y		
R	152-3	60" RCP AT 0.4%	263			Y

NOTE:
THE STORM DRAIN SEGMENTS IN THIS TABLE ARE ONES IN WHICH THE HYDRAULIC ANALYSES SHOW INSUFFICIENT NORMAL DEPTH CAPACITY TO CONVEY THE 10-YEAR FLOW (YELLOW AND RED LINES ON THE LEGEND). THIS TABLE INDICATES IF THE SEGMENTS HAVE CAPACITY TO CONVEY THE 10-YEAR FLOW UNDER PRESSURE. FOR SYSTEMS THAT CANNOT CONVEY THE 10-YEAR FLOW UNDER PRESSURE, THE TABLE INDICATES IF THE EXCESS FLOW CAN BE CONVEYED IN THE STREET OR WILL DIRECTLY ENTER AN ADJACENT LAGOON. ALL OF THE SEGMENTS MEET ONE OF THESE CRITERIA AND, HENCE, SATISFIES THE HYDROMODIFICATION EXEMPTION REQUIREMENT FOR CONVEYING THE 10-YEAR FLOW.

THE DRAINAGE AREAS ENCOMPASSING SEGMENTS A THROUGH L ARE ON STUDY AREA EXHIBIT SHEET 2. THE DRAINAGE AREAS ENCOMPASSING SEGMENTS M THORUGH R ARE ON STUDY AREA EXHIBIT SHEET 1.

LEGEND:

- MAJOR DRAINAGE BASIN BOUNDARY
- MINOR DRAINAGE BASIN BOUNDARY (SUBBASIN)
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- AS-BUILT PLANS SHOWING 10-YEAR OR HIGHER FLOW CONTAINED IN EXISTING PIPE
- NORMAL DEPTH ANALYSIS SHOWING 10-YEAR FLOW CONTAINED IN EXISTING PIPE
- NORMAL DEPTH ANALYSIS SHOWING EXISTING PIPE INCREASED BY ONE PIPE SIZE (6") TO CONTAIN 10-YEAR FLOW (SEE TABLE FOR DETAILS)
- NORMAL DEPTH ANALYSIS SHOWING EXISTING PIPE INCREASED BY MORE THAN ONE PIPE SIZE TO CONTAIN 10-YEAR FLOW (SEE TABLE FOR DETAILS)
- OUTLET INTO LAGOON
- A PIPE SEGMENT (SEE TABLE FOR DETAILS)

STUDY AREA EXHIBIT
HYDROMODIFICATION EXEMPTION

BATIQUITOS CREEK
DRAINAGE AREAS

HMP EXEMPTION EXHIBIT

ATTACHMENT B.2

HYDROMODIFICATION MANAGEMENT EXEMPTION MAPPING

Receiving Waters and Conveyance Systems Exempt from Hydromodification Management Requirements

Exhibit Date: Sept. 8, 2014

ATTACHMENT C
ELECTRONIC FILES

Electronic Folder titled "Carlsbad_WMAA_Attachment C Electronic_Data.zip" Contents:

1. ArcMap 10.0 and 10.1 map files created for purpose of viewing Regional WMAA data
    - WMAA_03_Carlsbad_Data_2014_0908_v10.mxd
    - WMAA_05_ Carlsbad_Data_2014_0908_v101.mxd
2. ESRI Geodatabase titled " WMAA_03_ Carlsbad_Data_2014_0908_v10.gdb" containing the following data:
    - WatershedBoundaries
        - Watershed_Boundaries
    - HydrologicProcesses
        - HRUAnalysis
    - Streams – description of existing streams in the watershed
        - SD_Regional_WMAA_Streams (streams selected for detailed analysis)
        - SD_NHD_Streams (portion of NHD dataset included for reference)
    - LandUsePlanning
        - SanGIS_ExistingLandUse
        - SanGIS_PlannedLandUse
        - SanGIS_DevelopableLands
        - SanGIS_RedevelopmentandInfill
        - SanGIS_MunicipalBoundaries
        - Federal_State_Indian_Lands
        - SanGIS_MHPA_SD
        - SanGIS_MSCP_CN
        - SanGIS_MSCP_EAST_DRAFT_CN
        - SanGIS_Draft_North_County_MSCP_Version_8_Categories
    - PotentialCoarseSedimentYield
        - GLUAnalysis
        - PotentialCoarseSedimentYieldAreas
        - MacroLevelPotentialCriticalAreas
        - PotentialCriticalCoarseSedimentYieldAreas
    - ChannelStructures
        - ChannelStructures
    - HydromodExemptions
        - Exempt_Systems
        - Exempt_Bodies
    - Floodplains: included for reference
        - FEMA_NFHL
    - Baselayers: included for reference
        - SanGIS_Lakes
        - link to ESRI World Imagery (internet connection is required to access ESRI World Imagery basemap)

Electronic Folder titled "Carlsbad _WMAA_Attachment C Electronic_Data.zip" Contents, continued:

3. Google Earth – KMZ file titled: "WMAA_03_ Carlsbad _Data_2014_0908_GoogleEarth.kmz", containing the following data:
   - WatershedBoundaries
   - Streams
     - SD Regional WMAA Streams (streams selected for detailed analysis)
     - SD NHD Streams (portion of NHD dataset included for reference)
   - LandUsePlanning
     - Municipal Boundaries
     - Federal/State/Indian Lands
   - ChannelStructures
   - HydromodExemptions
     - Exempt_Systems
     - Exempt_Bodies
   - Floodplains: included for reference
     - FEMA Floodplain
   - Dominant Hydrologic Processes
   - Potential Critical Coarse Sediment Yield Areas

Notes:

- Open a map file (with extension .mxd) using ArcMap to view the data.
- All data contained in the geodatabase is loaded into the map.

ATTACHMENT D
REGIONAL MS4 PERMIT CROSSWALK

Table below provides a linkage between the Regional MS4 Permit requirements for WMAA and this report.

Regional MS4 Permit Provision	Regional WMAA Report
B.3.b.(4)(a)	Chapter 2; Section 5.1; Attachment A and Attachment C
B.3.b.(4)(a)(i)	Section 2.1; Attachment A.1 and Attachment C
B.3.b.(4)(a)(ii)	Section 2.2; Attachment A.2 and Attachment C
B.3.b.(4)(a)(iii)	Section 2.3; Attachment A.3 and Attachment C
B.3.b.(4)(a)(iv)	Section 2.4; Attachment A.4 and Attachment C
B.3.b.(4)(a)(v)	Section 2.5; Attachment A.5 and Attachment C
B.3.b.(4)(b)	Chapter 3 and Section 5.2
B.3.b.(4)(c)	Chapter 4; Section 5.3; Attachment B and Attachment C